JOURNAL OF THE IRON AND STEEL INSTITUTE

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Incorporated by Royal Charter 1899

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132" 4-HIGH HOT PLATE MILL

AT CONSETT

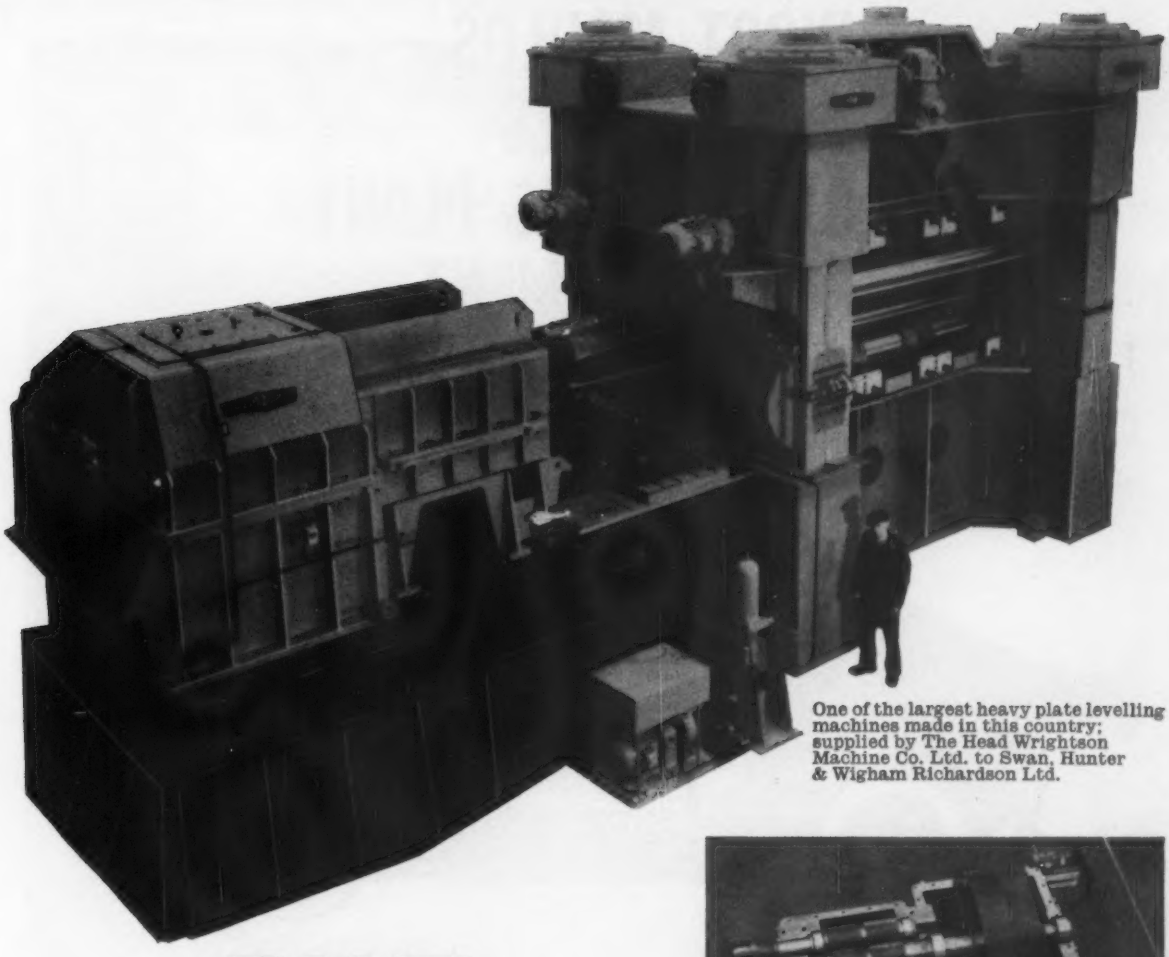
39" and 60" x 132" 4-High hot plate finishing mill in production, rolling plate up to 10 ft. wide, 90 ft. long

DAVY-UNITED | DAVY-ASHMORE GROUP

DAVY AND UNITED ENGINEERING COMPANY LIMITED · SHEFFIELD

LONDON · STOCKTON · GLASGOW · MIDDLESBROUGH · HULL · PARIS · MONTREAL · MELBOURNE · SYDNEY · JOHANNESBURG · SALISBURY · CALCUTTA · BOMBAY

506



One of the largest heavy plate levelling machines made in this country; supplied by The Head Wrightson Machine Co. Ltd. to Swan, Hunter & Wigham Richardson Ltd.

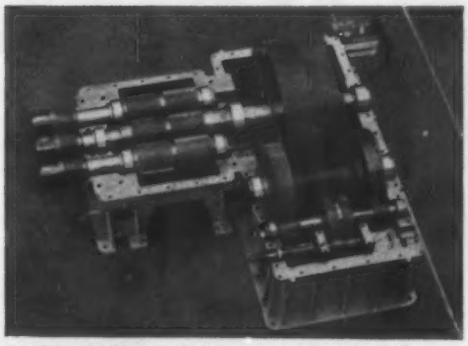
SKF

ball and roller bearings for this large plate levelling machine

Designed to handle ships' plates up to 2 in. thick and 12 ft. wide, this plate leveller is equipped throughout with SKF ball and roller bearings. Spherical roller bearings are used for the backing rolls and screw-down worm gear, and spherical roller thrust bearings—each carrying over 800 tons, for the screw-down shafts.

Entry and exit tables incorporate 112 standard SKF plummer blocks.

For efficiency and trouble-free operation, this heavy-duty installation depends to a large extent on the reliability of SKF ball and roller bearings.



Triple-reduction gear box equipped with SKF spherical roller bearings.

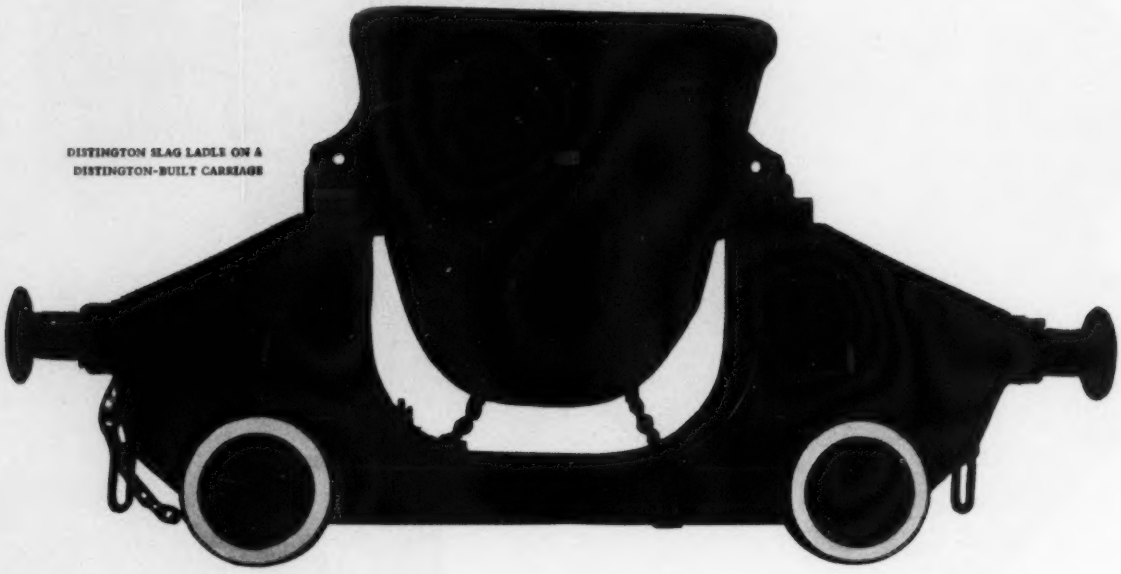
Backing rolls with special heavy duty housings for spherical roller bearings.

THE SKEFKO BALL BEARING COMPANY LIMITED · LUTON · BEDS

The only British manufacturer of all four basic bearing types: ball, cylindrical roller, taper roller and spherical roller.

INGOT MOULDS
SLAG LADLES
STEELWORKS PLANT
AND EQUIPMENT

DISTINGTON SLAG LADLE ON A DISTINGTON-BUILT CARRIAGE



are supplied by Distington Engineering Company Limited to many steelworks. The Distington's foundry has the highest output of any ingot mould foundry in Europe, and specialises in producing ingot moulds, bottom plates and slag ladles. It can handle castings up to 120 tons in weight.

OCTAGONAL FORGING INGOT MOULD

DISTINGTON

DISTINGTON ENGINEERING COMPANY LIMITED

WORKINGTON, CUMBERLAND

A subsidiary of The United Steel Companies Limited

CA.20

For a kitchen that looks really shipshape

An impressive display of stainless steel in the galley of S.S. Oriana. Photograph by Moorwoods Limited, Sheffield.

there's nothing to beat STAINLESS STEEL

This is the galley on board S.S. Oriana—immaculately modern in gleaming stainless steel. Where cleanliness and compactness are vital, stainless steel has more than good looks to recommend it. Hard-wearing, corrosion-resistant, and easy to keep clean, stainless steel catering equipment is fast becoming the obvious choice . . . for obvious reasons.

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Some people do . . . . .
in carbon steels required for certain high duty applications.

Residual elements in Workington Electric Arc Furnace Carbon Steel are as follows

	average	*maximum*
Nickel	·01	·02
Chromium	·01	·015
Copper	·03	·04
Arsenic	·015	·02
Tin	·015	·02
Vanadium	·02	·04
Molybdenum	*below* ·01	
Lead	*below* ·01	
Cobalt	·005	·008
Antimony	*below* ·01	
Tungsten	*below* ·01	
Titanium	*below* ·01	

WORKINGTON

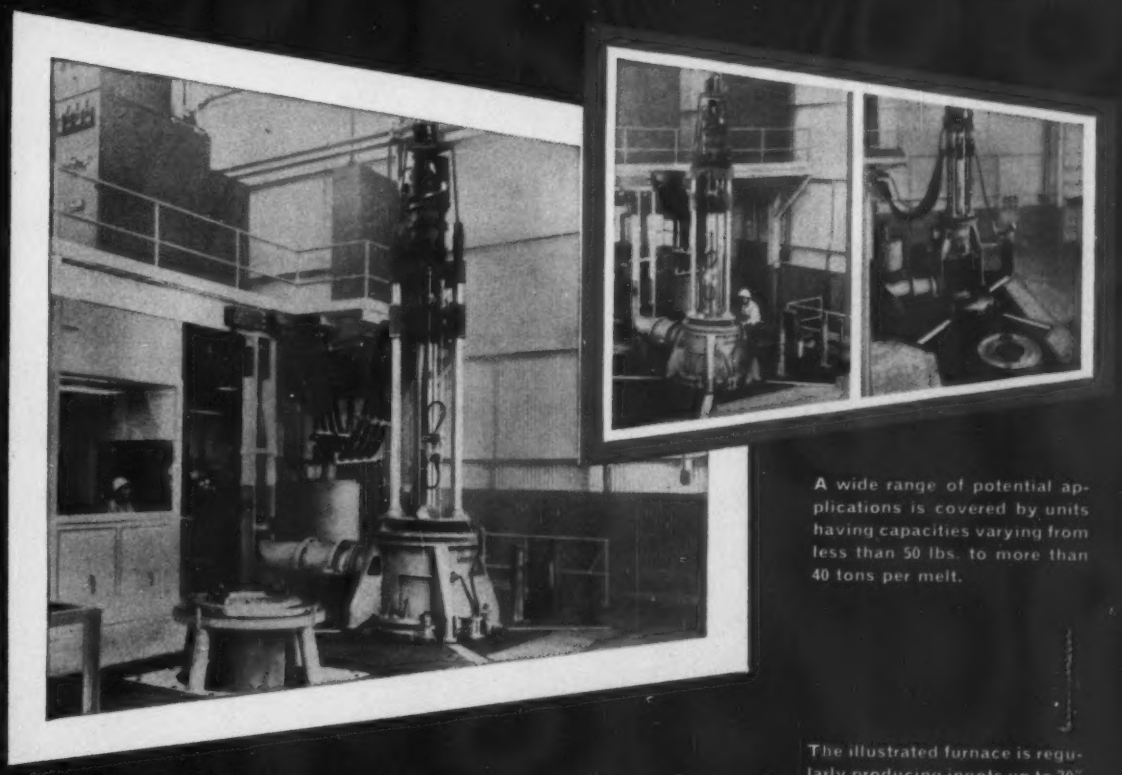
IRON AND STEEL COMPANY *Workington · Cumberland*

a branch of THE UNITED STEEL COMPANIES LTD

W 117

Special alloys of highest quality in quantity production at lower cost from *Lectromelt* Vacuum Arc Melting Furnaces

The consistent development in design of Lectromelt Furnaces* has now brought vacuum arc melting to the point where maximum production can be achieved at minimum cost, while maintaining the scrupulously high standards called for in the manufacture of special alloys. Automatic operation, which enables three men to handle two furnaces, a loading time as short as 20 minutes and sturdy design contribute to the unequalled economy of the unique Lectromelt system.



A wide range of potential applications is covered by units having capacities varying from less than 50 lbs. to more than 40 tons per melt.

30 inches diameter x 10 tons

The illustrated furnace is regularly producing ingots up to 30" diameter and 10 tons in weight and has an annual capacity of 8 million lbs.

*Lectromelt's accumulated knowledge and experience of melting and handling consumable electrode furnaces are available, confidentially, from

Stein & Atkinson Ltd.

Westminster House, New Road, Kingston, Surrey

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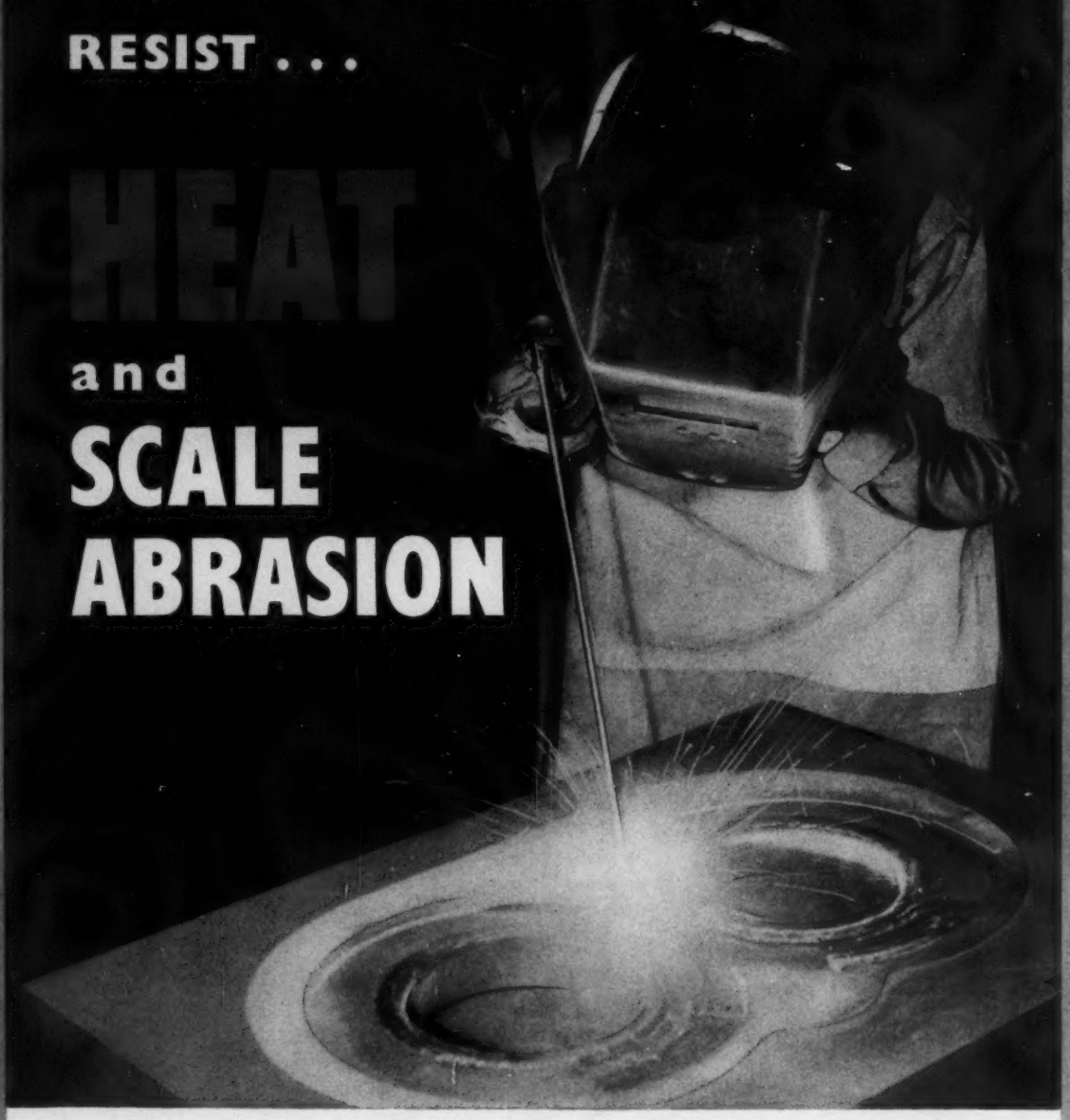
RESIST . . .

HEAT

and

SCALE

ABRASION



Components protected with "Stellite" show life increases of up to 500%
Applications include hot shear blades, ingot tong bits, roller twist guides, etc.
"Stellite" is applied by normal welding processes or the recently developed Spray-Fuse and Powder Welding methods.

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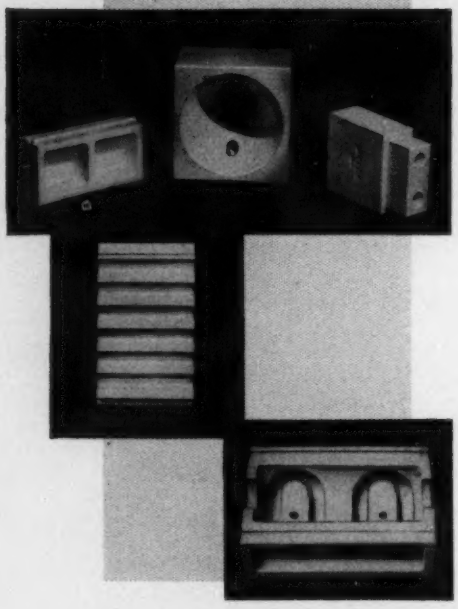
For Volume Stability at Extreme Temperatures



The ability of 'Mullox' bricks to show little or no volume change at extreme temperatures, plus an excellent spalling resistance, makes them ideally suited for all structures subjected to mechanical stress or thermal shock at high temperatures, e.g. burner blocks, combustion chamber linings, etc. Again, being chemically 'neutral' also, they withstand the corrosive action of most slags, and are not affected by oxidising or reducing atmospheres.

Examples of Recommended Applications

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(b) Burner Blocks.
(c) Gas Port Blocks.
(d) Burner Baffles.
(e) Hearth Tiles.
(f) Sidewalls.
(g) Roofs.
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ROTARY KILNS

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(b) Discharge Nose-rings.

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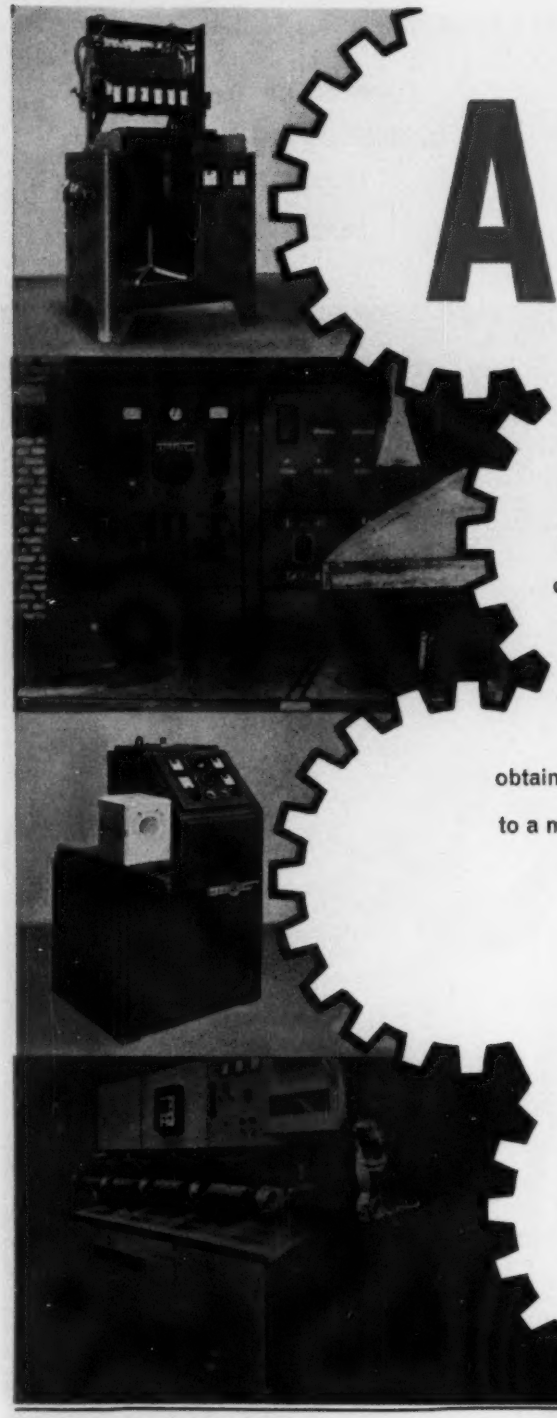

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Illustrations reading down

1. *160 kw 8 k/c Screw spike heater*
2. *2 melting furnaces of ½ ton capacity*
3. *100 kw 4 k/c heater for tubes*
4. *Continuous bar heater*

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Illustration: General view of an Open Hearth Melting Shop

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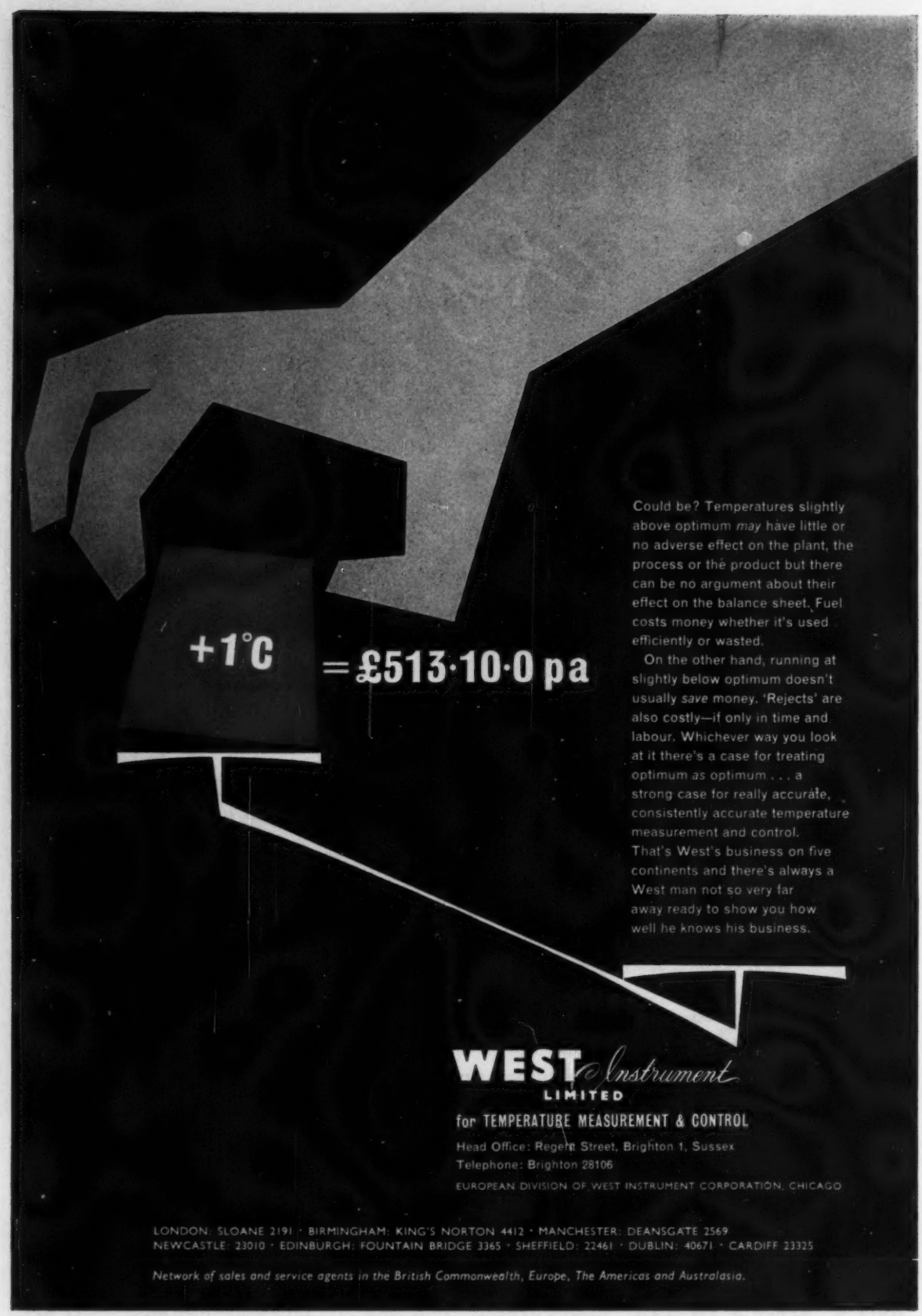

Could be? Temperatures slightly above optimum *may* have little or no adverse effect on the plant, the process or the product but there can be no argument about their effect on the balance sheet. Fuel costs money whether it's used efficiently or wasted.

On the other hand, running at slightly below optimum doesn't usually *save* money. 'Rejects' are also costly—if only in time and labour. Whichever way you look at it there's a case for treating optimum as optimum . . . a strong case for really accurate, consistently accurate temperature measurement and control. That's West's business on five continents and there's always a West man not so very far away ready to show you how well he knows his business.

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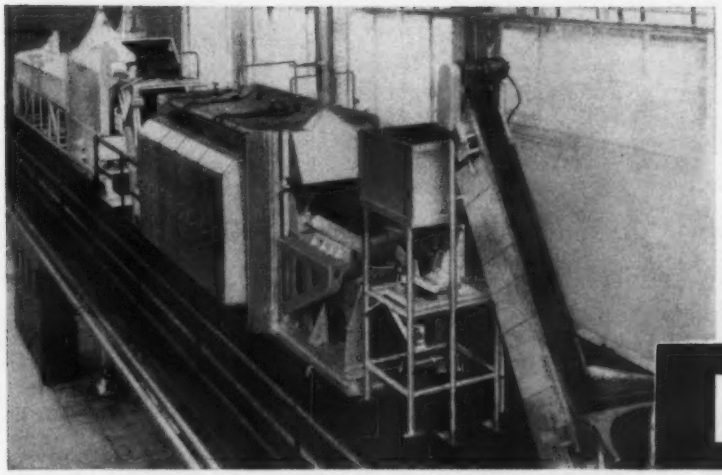
tapered roller bearings

who

use



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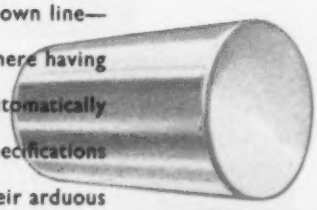
At British Timken, rollers have their own line—an EFCO continuous production line—where having been previously carburised they are automatically hardened and tempered to the precise specifications necessary for them to perform their arduous duties for British Railways.



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the best of the world's furnace designs

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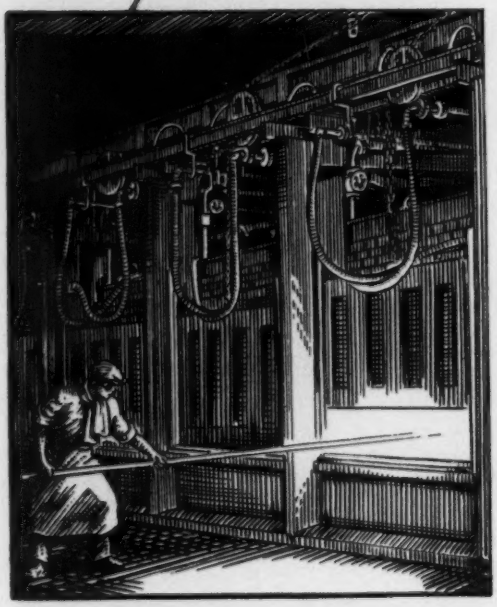

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Hexagons $\frac{3}{8}$" to $\frac{9}{16}$" in 500 lb. coils.
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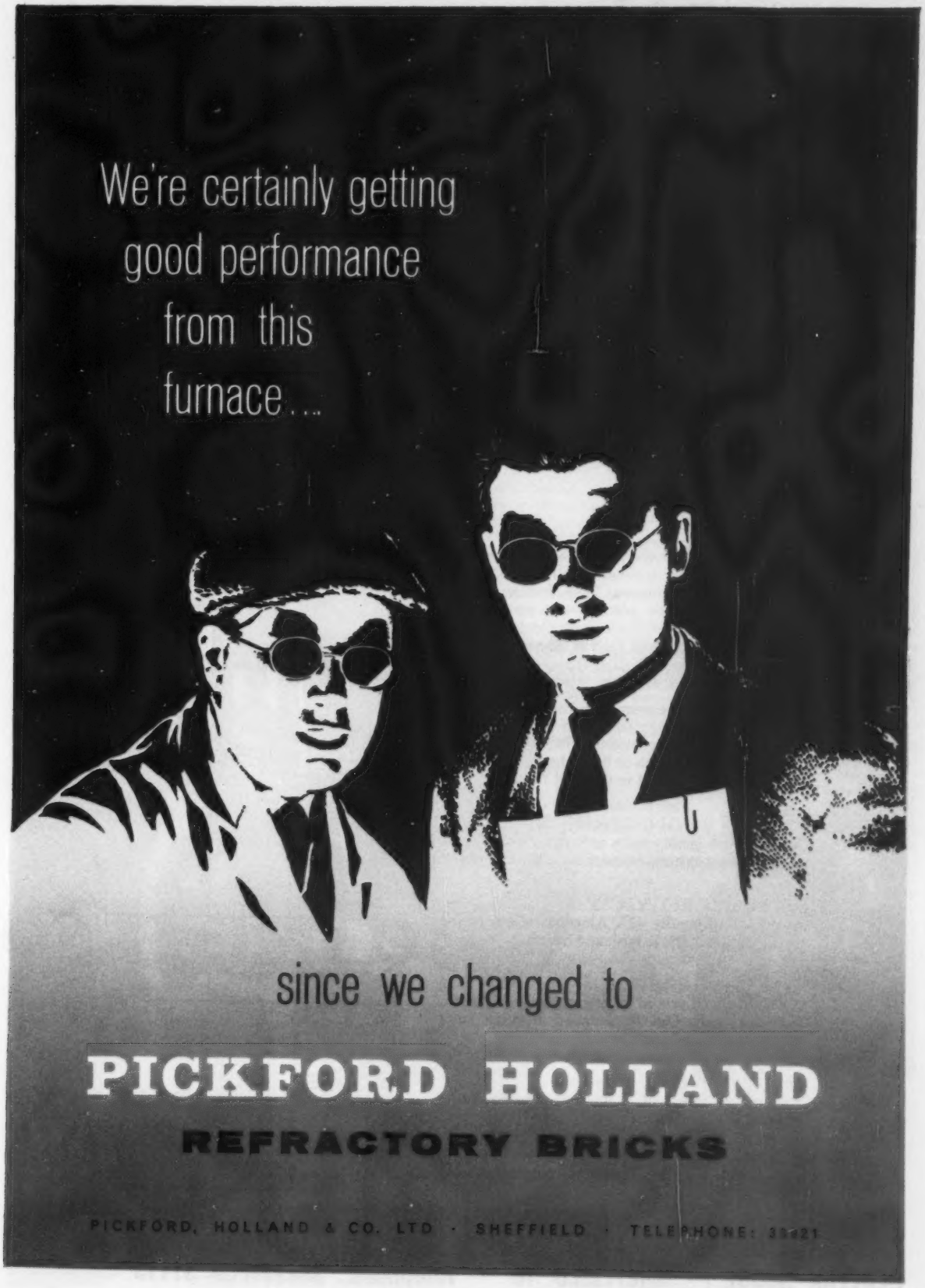
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from this
furnace...
since we changed to
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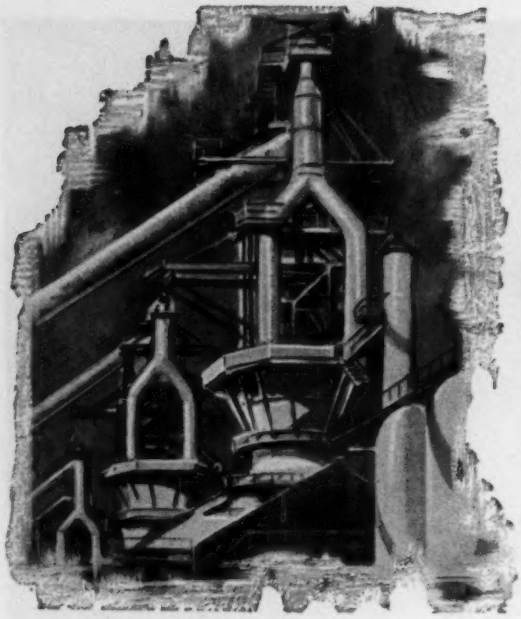

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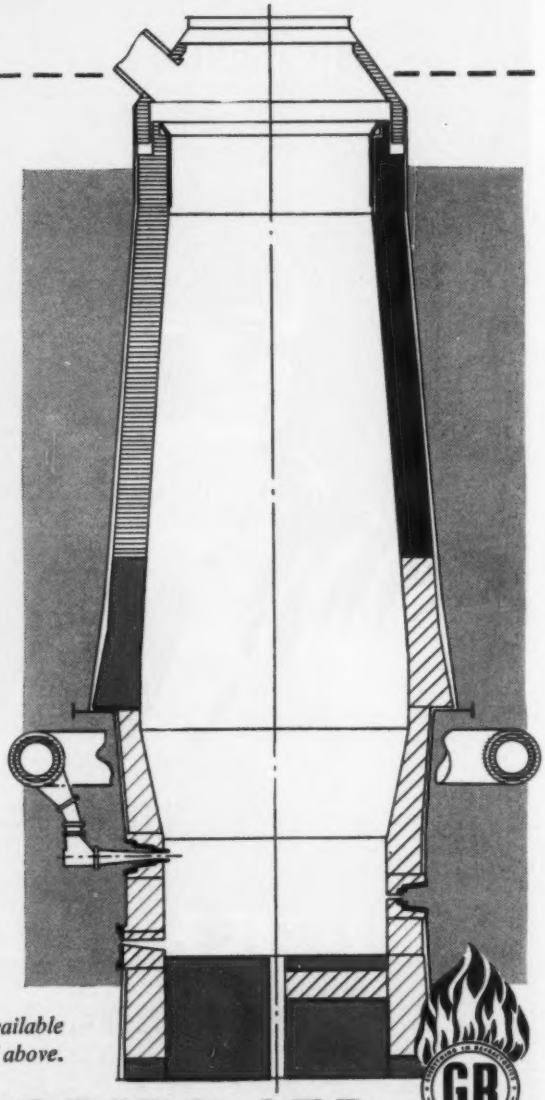
BLAST FURNACE REFRACTORIES



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A new dense, high fired refractory to meet the most exacting conditions encountered in the stack in modern furnace operations. Main features of this refractory are very low porosity, high resistance to abrasion and a very low iron content which makes for complete immunity from carbon monoxide attack.

SILLMAX 'I'
A 100% bondless Sillimanite refractory of highest purity and low porosity for use in the lower stack, bosh and hearth. Very resistant to slag and alkali attack and volume stable at the highest temperatures likely to be encountered in the blast furnace.

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An improved quality 42% Alumina refractory for use in the lower stack, bosh and hearth.

FOSTER CARBON
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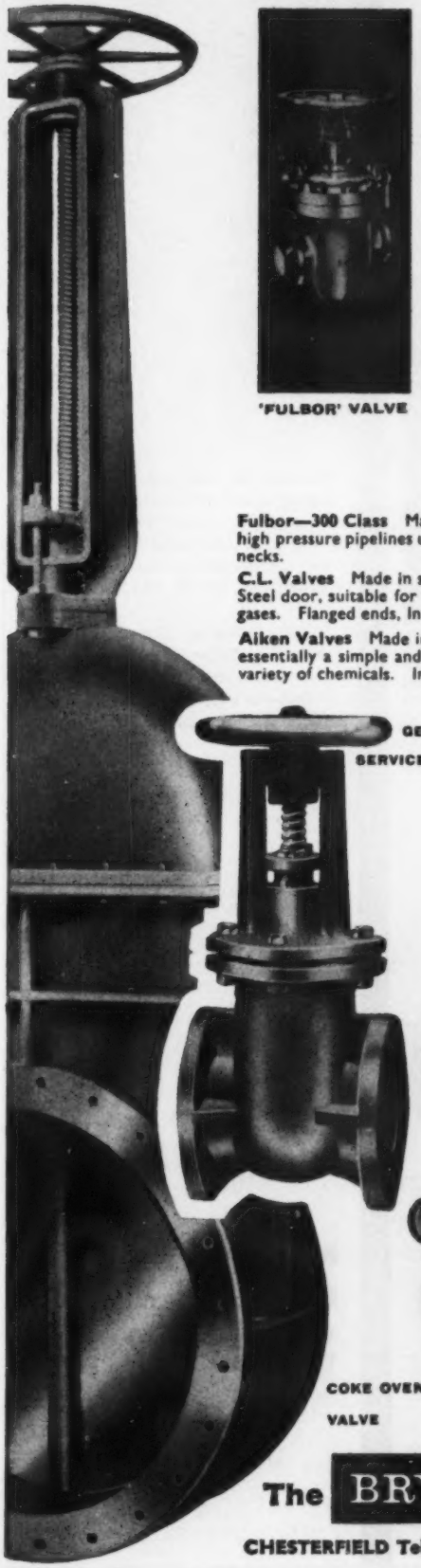
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Baurer Valves Medium pressure valve, made in sizes from 4" to 48" Bore, or larger if required, with cast iron or fabricated mild steel bodies. Working pressure on large sizes up to 45 p.s.i.g. Internal or External Screw operation.

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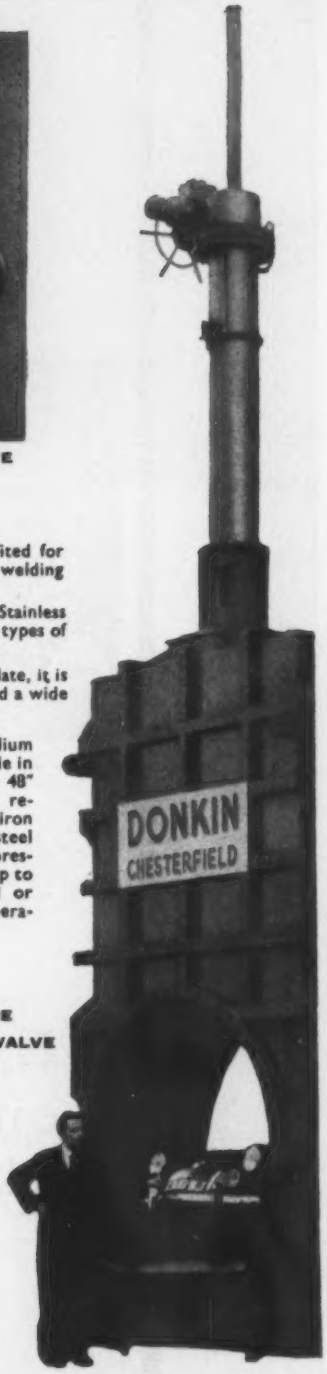
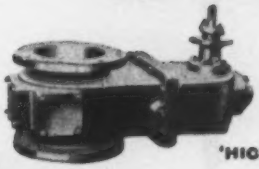


90" BORE 'SEALBOR' VALVE

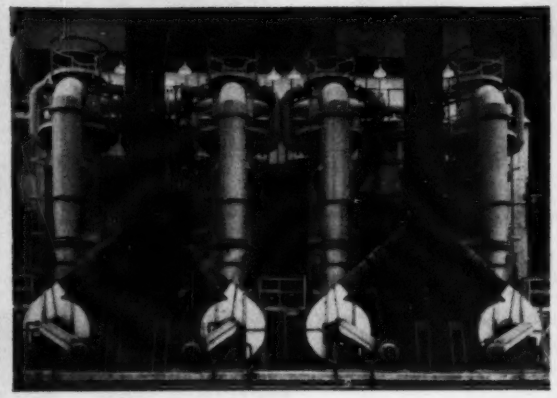
NON-RETURN VALVE

COKE OVEN VALVE


'HICKS' VALVE

The BRYAN DONKIN Company Limited

CHESTERFIELD Telephone 3153 **LONDON Telephone ABBey 1096**



Four one-way fired soaking pits equipped with ME/Schack combined concentric air recuperators for pre-heating the combustion air to 780°C.; and flue tube gas recuperators for pre-heating blast furnace gas to 520°C.

Installed by Messrs. Wellman Smith Owen Eng. Corpn. Ltd. for Messrs. Richard Thomas & Baldwins Ltd., Redbourn.

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Railko bearings are tough, resin-impregnated fabric laminates moulded under heat and pressure to provide specific properties which include low friction losses, reduced wear, longer trouble-free life. They withstand severe operational extremes and can be used where conventional lubrication is difficult or impossible. Self lubricating types are available for many applications.

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The "Margam Abbey"—built for the Port Talbot Pilotage Authority by Richard Ironworks Ltd., in which Cor-Ten was used extensively. Photograph by courtesy of the Port Talbot Pilotage Authority

COR-TEN GOES DOWN TO THE SEA IN SHIPS

At sea as well as ashore new uses are constantly being found for SCW Cor-Ten. It was used extensively in the construction of this vessel for the Port Talbot Pilotage Authority.

The Main Deck and Bulwark Plating
Shell Plating and Anchor Recess
Floors and Engine Seating
Chain Locker
Fresh Water Tank
Bulkhead Bottom Plating
Rudder Side Plates

—were made entirely from Cor-Ten. A typical example of the growing use of Cor-Ten in marine construction, and in other fields where high yield strength, together with outstanding resistance to corrosion, is vital.

COR-TEN IS TOUGHER

Weight for weight, the yield strength of SCW Cor-Ten is 50% higher than ordinary mild steel.

Alternatively—
Strength for strength, a saving of 1/3 of the weight is possible.

4–6 times more resistant to atmospheric corrosion. Highly resistant to abrasion and fatigue.

COR-TEN SAVES MONEY

Initial costs are spread over a longer service life.

Maintenance costs are reduced.

Operating costs are lowered—in transport, payloads are bigger because of reduction in tare weight.

Please write to us at the address below for further information or for technical assistance in the application of SCW Cor-Ten to your products.

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have acquired

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Patent applied for

specially designed and manufactured by

LLOYDS (BURTON) LTD

for use in the

Drying and Pre-heating of Ladles

*

THE LLOYDS LADLE HEATER OFFERS THESE ADVANTAGES

1. The heating is rapid and uniform, and kind to the refractories.
2. The heater gives a predictable heating cycle and greater availability of ladles.
3. It requires substantially less fuel.
4. It is easily used and maintained.

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STORRS BRIDGE WORKS, LOXLEY, NR. SHEFFIELD. **Tel. 343844/8**

For the right proportions...

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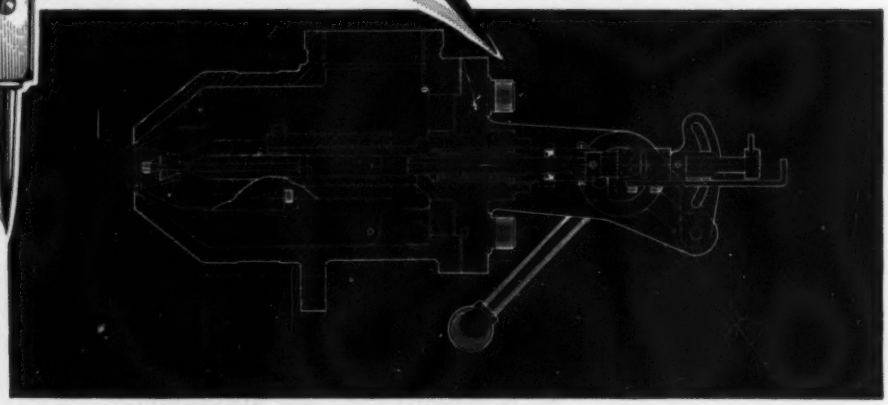
SELF-PROPORTIONING OIL BURNERS FOR CONSTANT AIR-OIL RATIO

Pioneered by Schieldrop in Great Britain, self-proportioning oil burners offer outstanding advantages including peak efficiency and real economy of operation. Write for full details of Schieldrop burners.

Note these features—

1. Single lever control.
2. Easy adjustment for high and low flame settings.
3. Simple and robust construction.
4. Constant velocities of both primary and secondary atomising air, giving uniform flame over a 5-1 turn-down range.



Schieldrop & COMPANY LIMITED

STOTFOLD, BEDS. Phone 414 (4 lines)

2 OR 12000 TONS

of steel per week—pickled. In a single acid bath or continuous lines handling 72" strip at 400 ft./min.

And it's all done by Kestner. Kestner will supply whatever is required, from just one tank to a complete installation, wholly designed and engineered by themselves. They have, in fact, been doing precisely this for years so that there are now innumerable pickling plants all over the world which are Kestner-equipped to a lesser or a greater degree. If it's not the entire process—as in many instances it is—it might well be the Acid Handling System, or the Fume Extraction equipment, or the Acid Recovery plant, or simply the Pipework or, indeed, any of the ancillary equipment that goes into Batch, Spray or Continuous Pickling. It was Kestner, too, who developed Keebush, the completely anti-corrosive thermo-setting plastic that needs no maintenance and lasts indefinitely. Kestner can build very much the major part of their equipment of this material. When Keebush was introduced more than thirty years ago it even then confirmed the leadership which unsurpassed skill and experience have established for Kestner in the vital field of steel pickling.

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CHEMICAL ENGINEERS

KESTNER EVAPORATOR AND ENGINEERING CO. LTD., 5 GROSVENOR GARDENS, S.W.1. VICTORIA 8975
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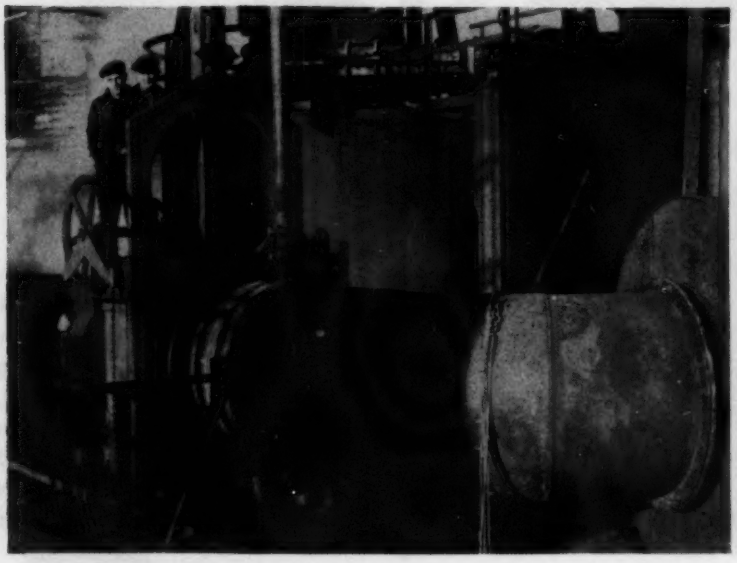
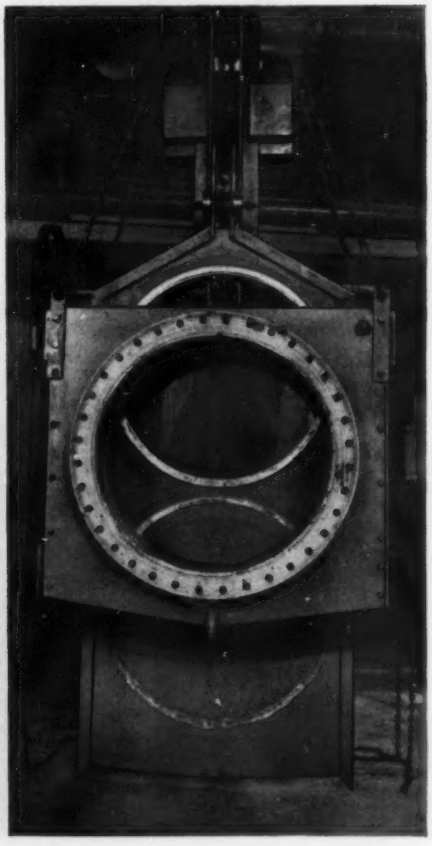
BARROW-KINNEY PLATE TYPE GOGGLE VALVES FOR POSITIVE GAS CONTROL

Reproductions show 42″ valve recently completed and as erected in gas main for British Cellophane Ltd.

Note these outstanding features:

- ★ Robust construction ensures long trouble-free service
- ★ Rigid flanges—positive clamping—easy erection
- ★ Built-in readily accessible centralised greasing
- ★ Fast easy manual operation—alternatively, motor operated valves can be supplied





Standard size range: 18″ to 108″ bore. For vertical or horizontal installation. Totally enclosed if required. Copper seated for clean gas, resilient seated for hot, dirty gas. We will gladly demonstrate or supply further information.

BARROW IRONWORKS LTD

P.O. BOX NO. 5 Barrow-in-Furness, Lancs. Telephone Barrow 830 (5 lines) Grams Ironworks, Barrow
Blast Furnace Equipment Manufacturers – General Engineers – High Grade Haematite Pig Iron Makers

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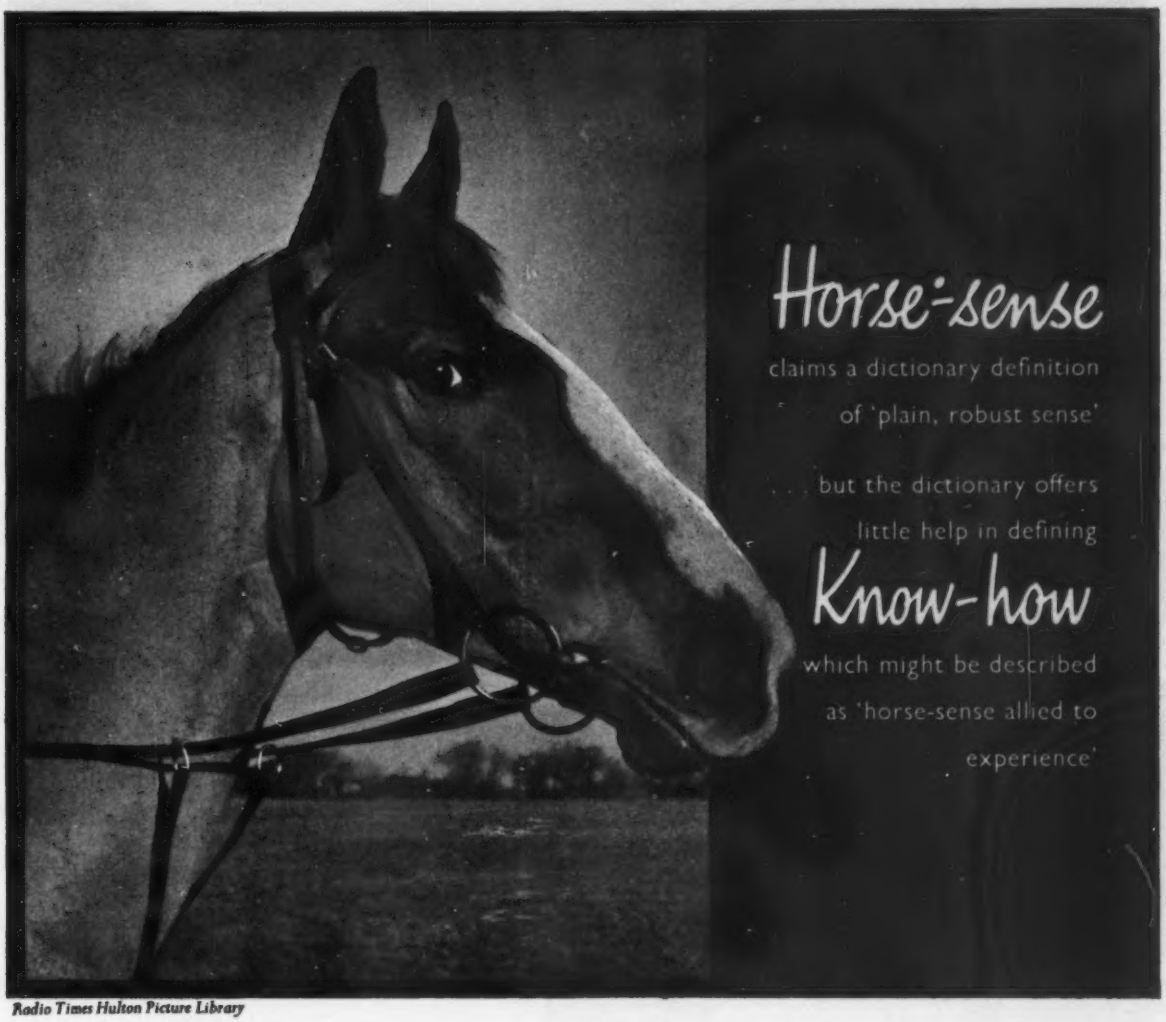

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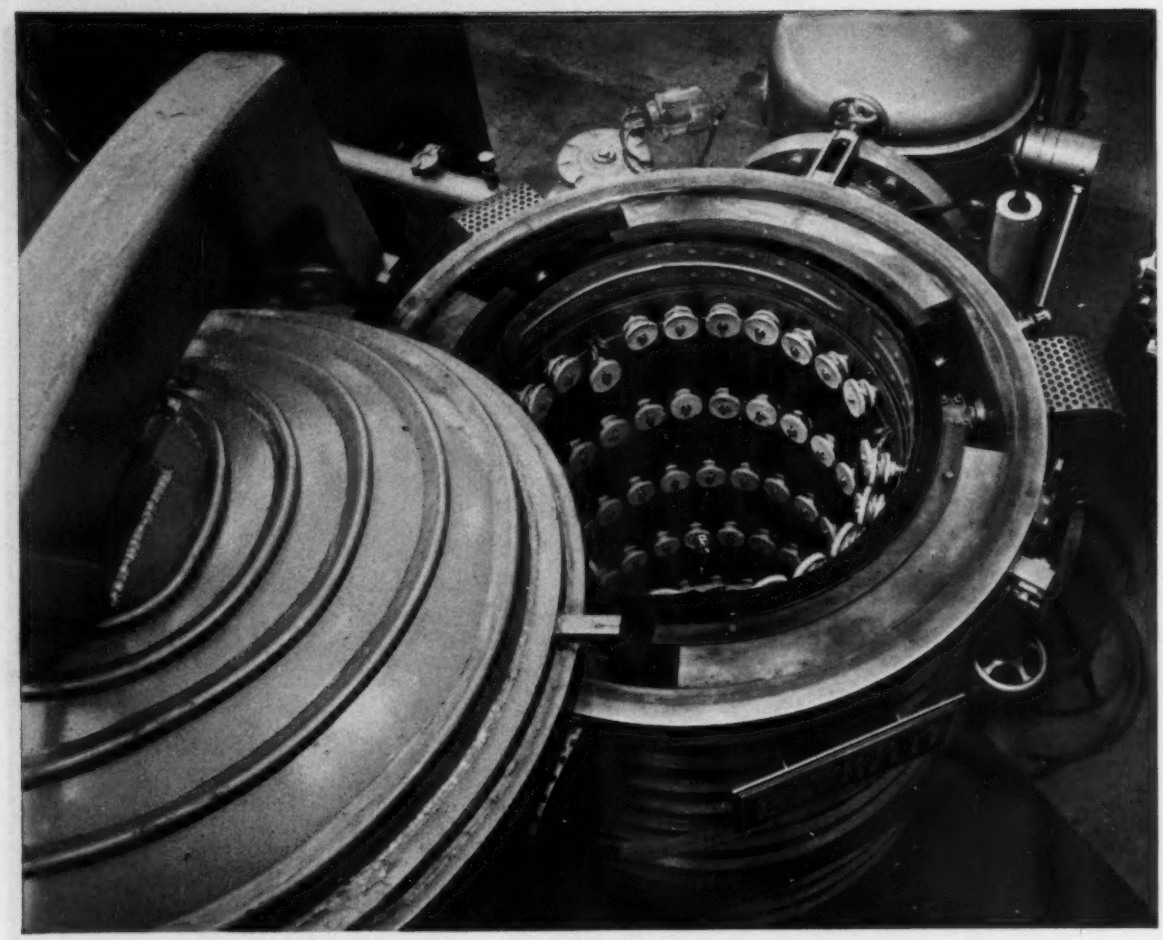
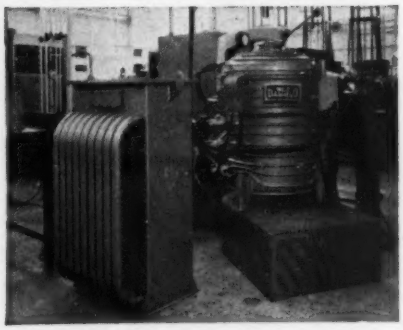


Vacuum Brazing at S.E.R.L. Harlow

The advantages of vacuum brazing include extremely clean work and joints of great strength, free from pinholes and made without fluxes.
That is why the Services Electronics Research Laboratories (Microwave Electronics Division) at Harlow are using the Wild-Barfield internal element type vacuum furnace shown for brazing special assemblies.
Remember that the experience of Wild-Barfield covers the design and manufacture of all types and sizes of vacuum furnaces.



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Steel-making in Wales

Mitchell conveyors have been carrying raw material into the blast furnaces of Wales day in, day out since 1937

Just a single Mitchell tippler and conveyor system at one Welsh steelworks has been handling 15,000 tons of coal, coke, ore and sinter a day for many years.

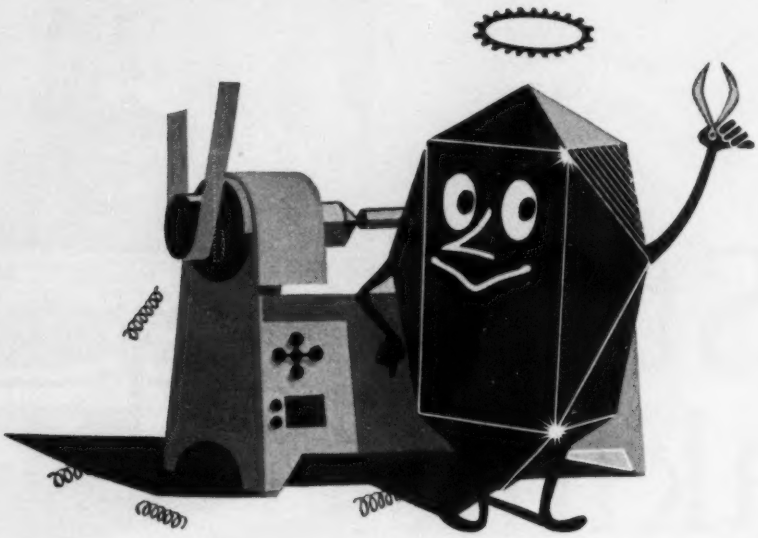
And now Mitchells are well advanced on a £2,500,000 contract for a new materials handling system at Richard Thomas and Baldwins' new Spencer Steelworks near Newport.

Mitchells are also active in the fields of boiler design, cableways and ropeways, wagon handling, transporters and conveyors, cranes, mills, ship loading plant and nuclear power.

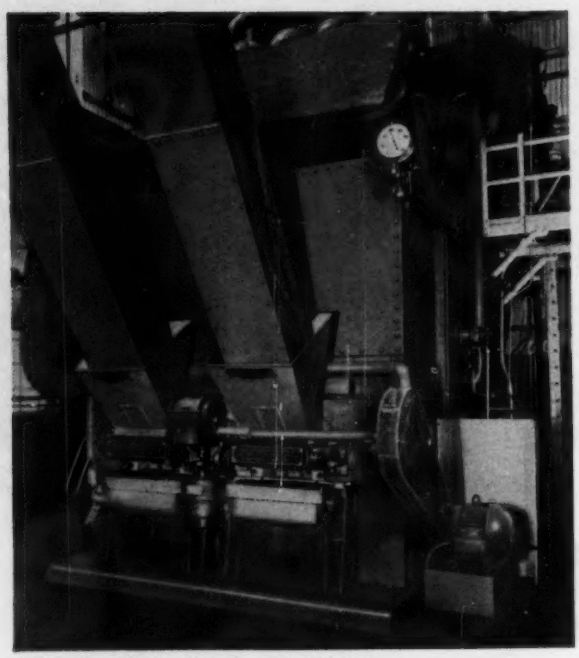
This Mitchell conveyor carries ore to Britain's biggest blast furnace

MITCHELL

MITCHELL ENGINEERING LIMITED · ONE BEDFORD SQUARE · LONDON



COAL-properly used-
is the cheapest fuel for the Light Engineering Industry



Coking stokers feed coal continuously, quietly and invisibly into this boiler.

Much of the prosperity of Britain rests upon the growing strength of the Light Engineering Industry—an industry that embraces both small workshops and the vast and complex factories employing thousands of people. Obviously, every light engineering works has to keep its products priced as keenly as possible in the face of the rising costs of labour and raw materials and the economic pressures from both domestic and foreign competition. This calls for shrewd management and the sound assessment of every possible economy on a long-term basis.

BEGIN AT THE BEGINNING-THE BOILERHOUSE

There are still some industrial concerns that handicap their finances with outdated boilerhouses. To modernise other machinery while 'making-do' with inefficient boilers is to throw good money down the drain. Modern coal-burning installations can be so efficient that they will more than pay for themselves in a remarkably short time. They are, without question, the first essential in a factory that is going to make rising profits for its management.

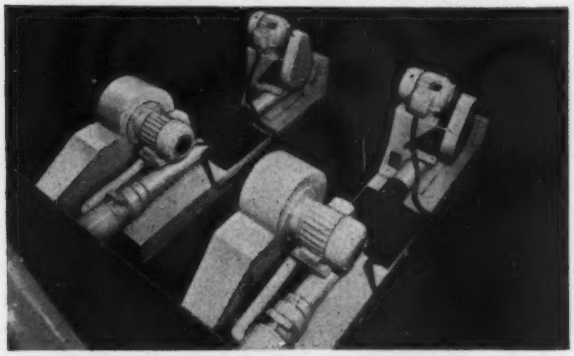
COAL IS THE RELIABLE FUEL

One question for any long-term planning is obvious: can supplies of coal be guaranteed? The answer is yes—without qualification. The mining industry, Britain's largest single industry, is becoming increasingly efficient; its equipment is the best of its kind. And British coalfields contain enough coal to supply every industrial demand for centuries to come.

COAL IS CLEANER, HOTTER

Modern grading and washing methods ensure that coal is the most efficient and consistent fuel for every type of boiler—the ideal fuel for every section of the light engineering industry. But to obtain the maximum heat at the lowest cost, coal should be mechanically stoked. A mechanical stoker automatically feeds the right amount of coal for the boiler load even when the load is varying; it burns coal at optimum efficiency all the time without the emission of smoke (thus complying with the regulations in Smoke Control Areas) and it virtually replaces the human element in boiler operation.

There are many types of mechanical stokers, of which the most commonly used are the Chain grate stoker, the Coking stoker, the Underfeed stoker and the Sprinkler stoker. Standard models are available for all sizes of boiler.



Two underfeed stokers transferring coal direct from a storage hopper into a modern vertical boiler.

OVER 80% OF BRITISH INDUSTRY USES COAL

The National Coal Board is determined that coal shall continue to be plentiful, shall continue to keep our industrial power both dominant and progressive. You can depend upon coal: its sources and supply are in our own hands—free from the fluctuations of foreign policies. Endless research by scientists and chemists working in the laboratories of the N.C.B. will ensure that coal will be increasingly profitable for its users.

DELIVERY-ON THE DOT -ON THE SPOT

The delivery of industrial coal is today highly organised and reliable. Leading coal merchants have completely overhauled delivery and storage systems and are fully equipped to make sure that you get the right grade of coal when you want it and where you want it.

Furthermore, completely mechanised handling systems will transport coal from storage to furnace without any manual labour at all.

FINANCE PLAN FOR INDUSTRY

No deposit, repayments spread over five years, low interest charges that can be set against Tax, full investment and other capital allowances that can be claimed at once; these are the terms available to the manufacturer or businessman who wants to install modern coal-burning equipment without touching his capital resources.

Make use of the National Coal Board Industrial Finance Plan. The loans are made by Forward Trust Limited, who are members of the Midland Bank Group. A 'phone call or a letter to the regional office of the National Coal Board will bring you full details.

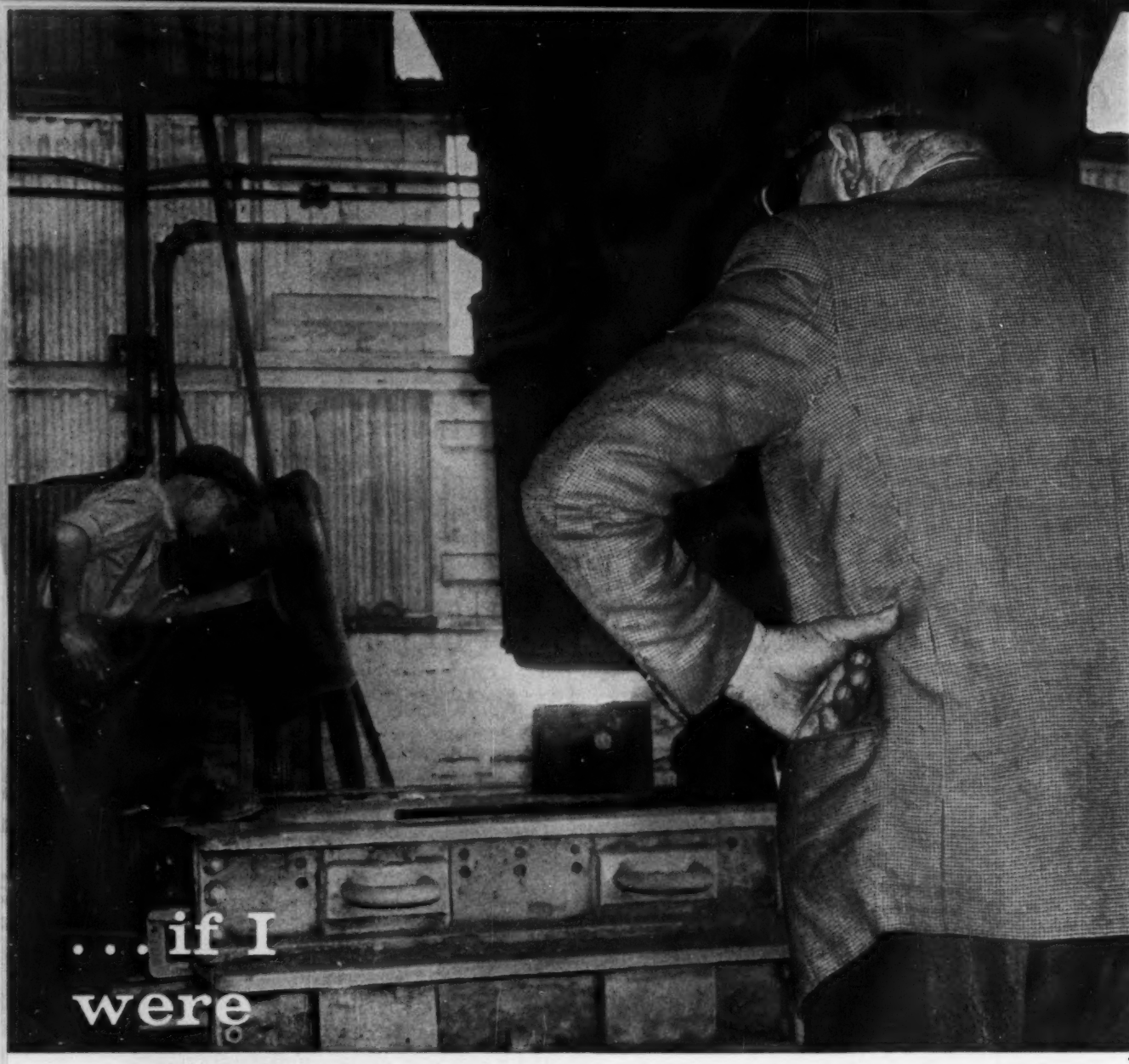
AND-WHEN YOU NEED IT A NATION-WIDE FREE SERVICE

At a flick of your finger, you can call upon one of the most comprehensive and efficient technical services in the world. Call either your coal supplier or the regional office of the NCB for an authoritative answer to your problem.

SOLID FUEL—more heat at less cost—and it's British

PROGRESSIVE INDUSTRY IS GOING FORWARD ON COAL

ISSUED BY THE NATIONAL COAL BOARD



a Q.C.

"...'Members of the Jury' I'd begin—and I reckon that would be my lot.

"You want a cool, calculating brain to tackle a job like that. Every step planned in advance—on your toes every minute of the day and heaven help the client if you make a mistake.

"A bit like casting a roll when you come to think of it—except for the talking. Always one move in front of the metal, every detail worked out to a hair-breadth and all the time Charlie, the crane driver, is sitting in his box like a blooming judge.

"As for the Jury? Well, I reckon all of us at AW fill that bill, but speeches won't sway us—it's the **result** that counts here."

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VITREOSIL pure fused silica tubes are ideal for this purpose. They are thoroughly uniform and homogeneous, and remain constant in physical and chemical characteristics even up to 1050°C.

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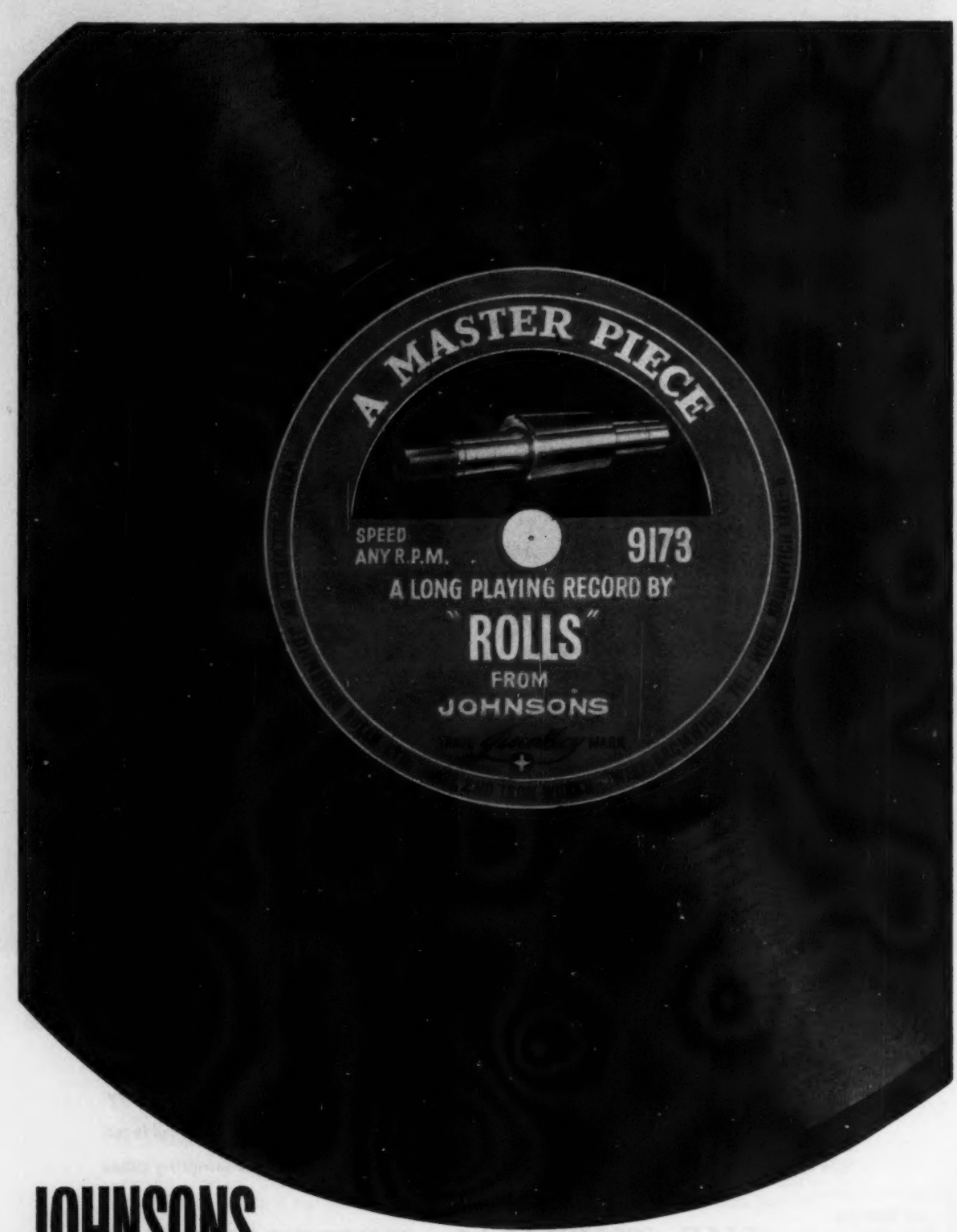

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☛STELVETITE–
plastic bonded to steel has put a new face on L.D.E.P. CONTROL UNITS

Asked to make this control unit for a new production line, Lancashire Dynamo Electronic Products Ltd., leaders in the field of industrial control equipment, found they were able to imprint instructions on the vinyl by the Masseeley process. Previously they had fitted separate instruction panels after the units had been made.

Because Stelvetite eliminates this, together with need for surface finishing, and can be worked like ordinary sheet steel, L.D.E.P. have decided to use it extensively instead of stove-painted panelling.

This is saving the company production costs and time, in addition to making their units resistant to the difficult corrosive atmospheres encountered in industry.

All enquiries about the L.D.E.P. Control Unit should be addressed to Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs.

Stelvetite

Plastic bonded to Steel

* *Accepted by the Council of Industrial Design for "Design Index*

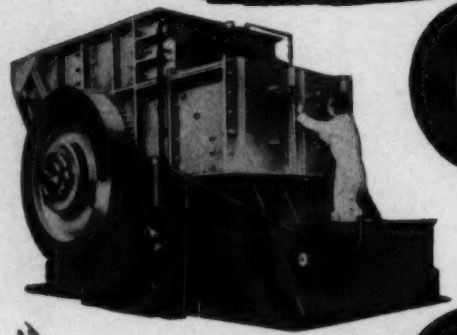
*STELVETITE—made in co-operation with BX Plastics Ltd. by

JOHN SUMMERS & SONS LTD

Write to us at Dept. JS · Shotton · Chester · for full information

FOR IRON ORE CRUSHING IN SINTER PRODUCTION

Over 90 per cent of the tertiary crushing of wet and sticky ores in British steelworks is done by Pennsylvania Dixie Non-Clog Hammermills.



This, the largest hammermill ever produced in Britain, was built at the Erith Works of G.E.C.

RELY ON THE EXPERIENCE OF

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For further information, write to:

The General Electric Company Limited of England Fraser & Chalmers Engineering Works Erith Kent

483

Centre of attraction

To the expert's discerning eye, a centre brick made by Wraggs of Sheffield represents all that's finest in casting pit refractory manufacture. In addition to perfect external shape and accuracy of dimensions, the smooth internal finish ensures that no refractory inclusions are picked up by the metal during pouring.

These attributes stem from years of specialisation in the casting pit refractory field, in which Wraggs were pioneers. And they all add up to the solid reliability demanded by to-day's busiest steelmakers.

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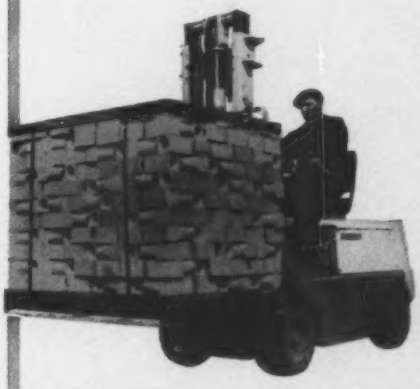

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for Mixing
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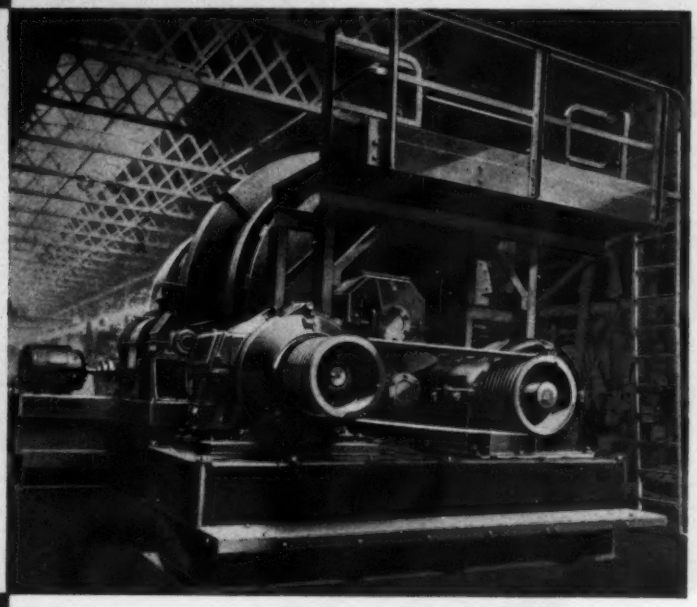

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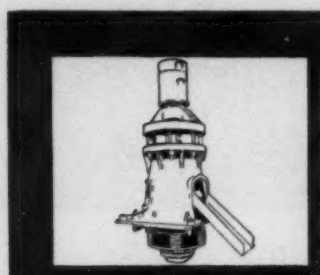

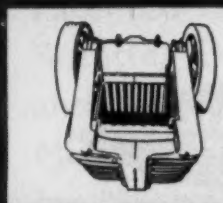

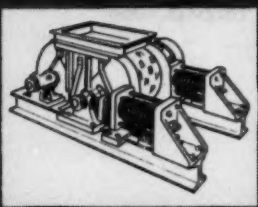

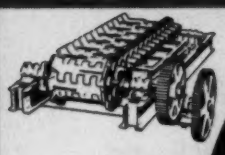

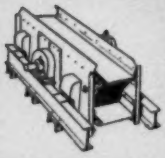

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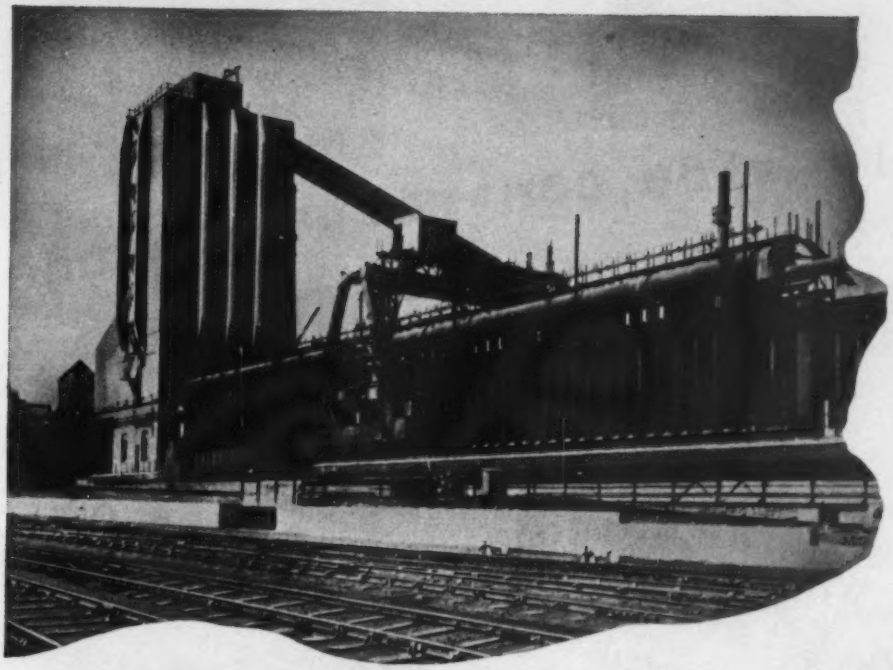

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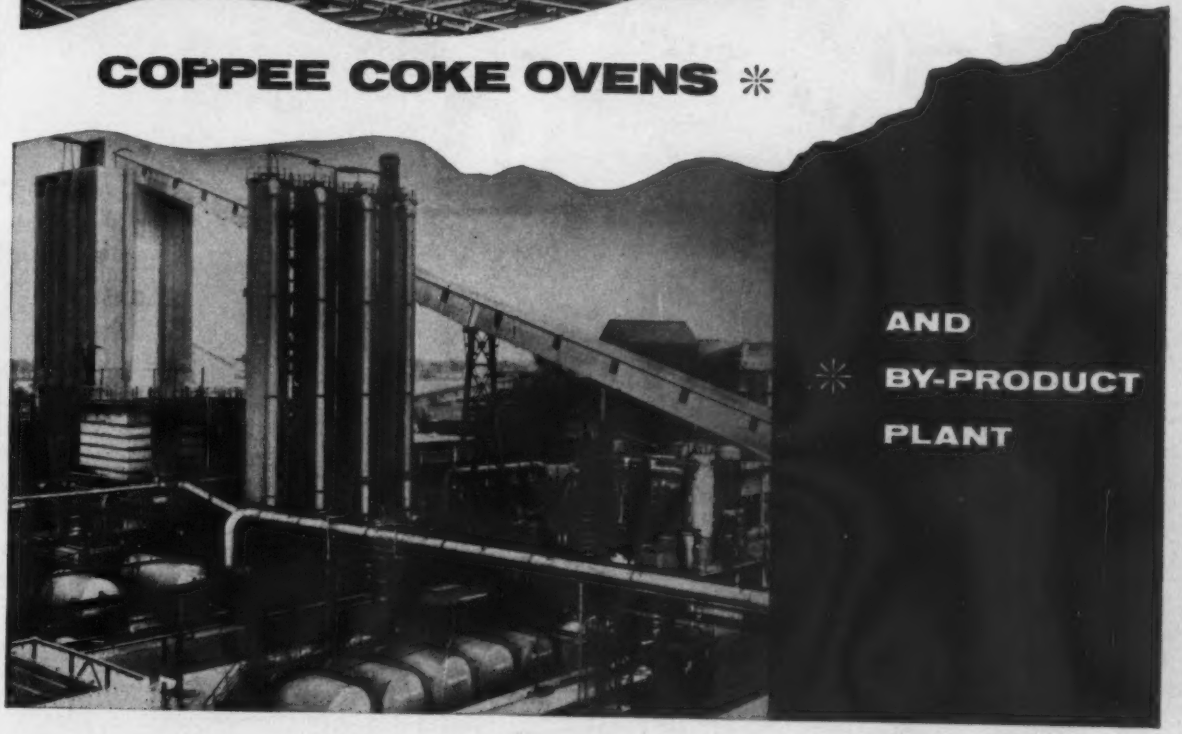

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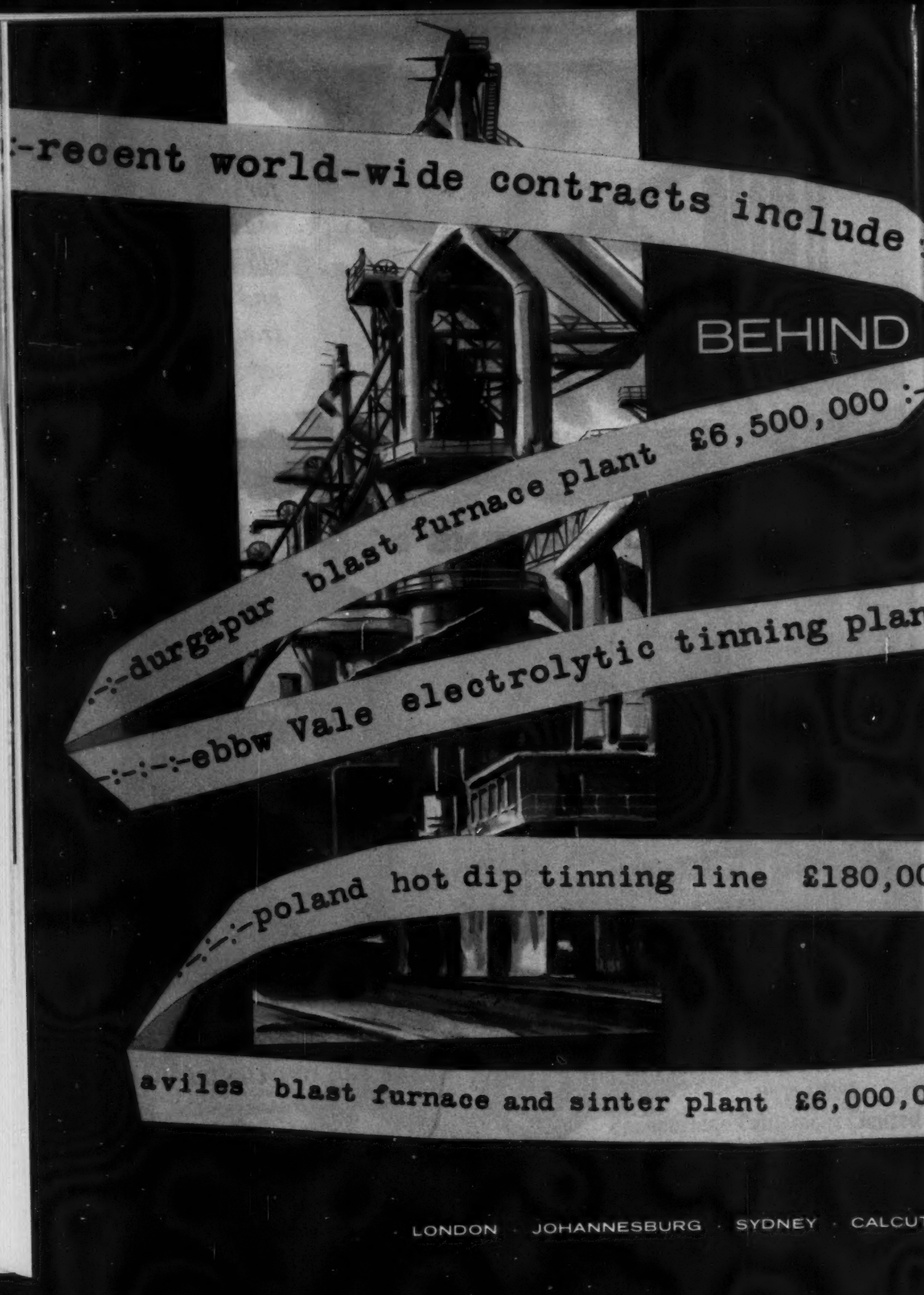
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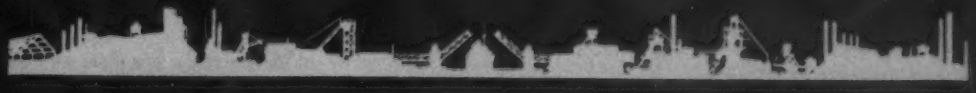

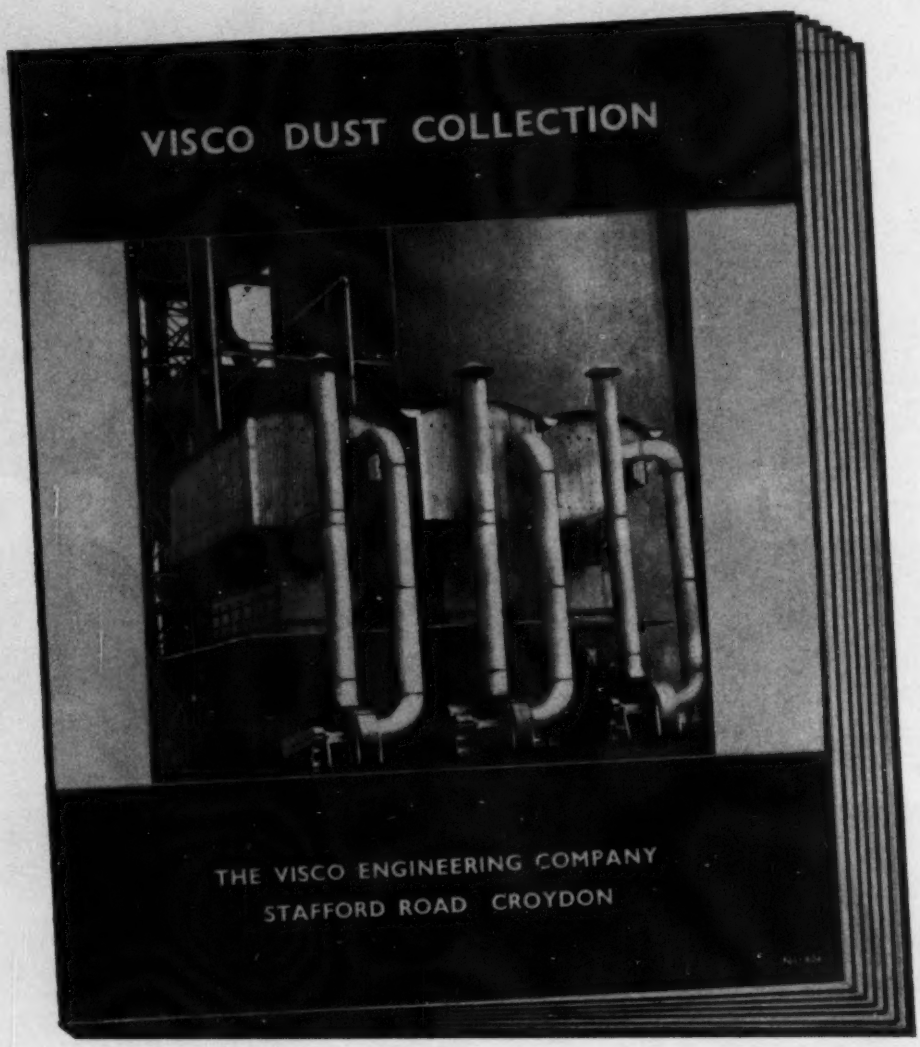

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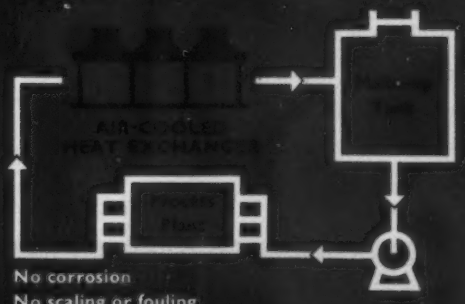

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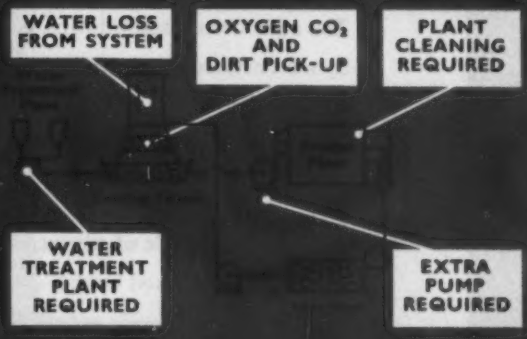

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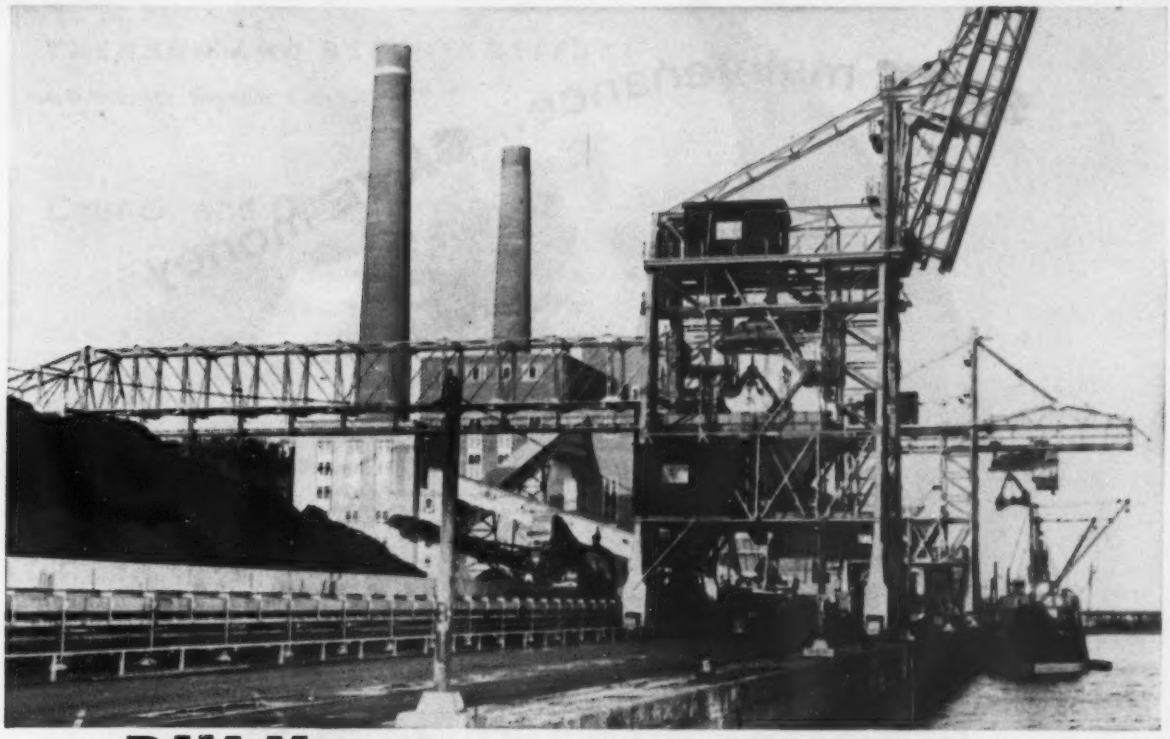

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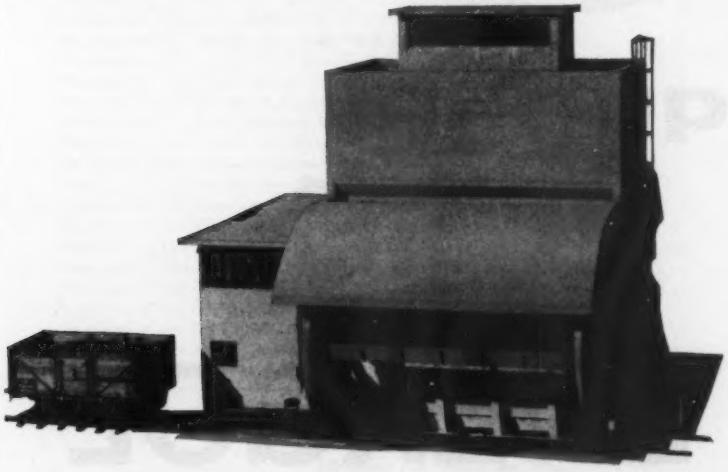

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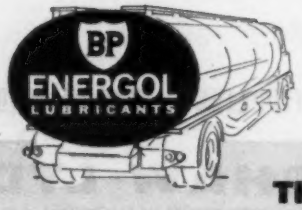

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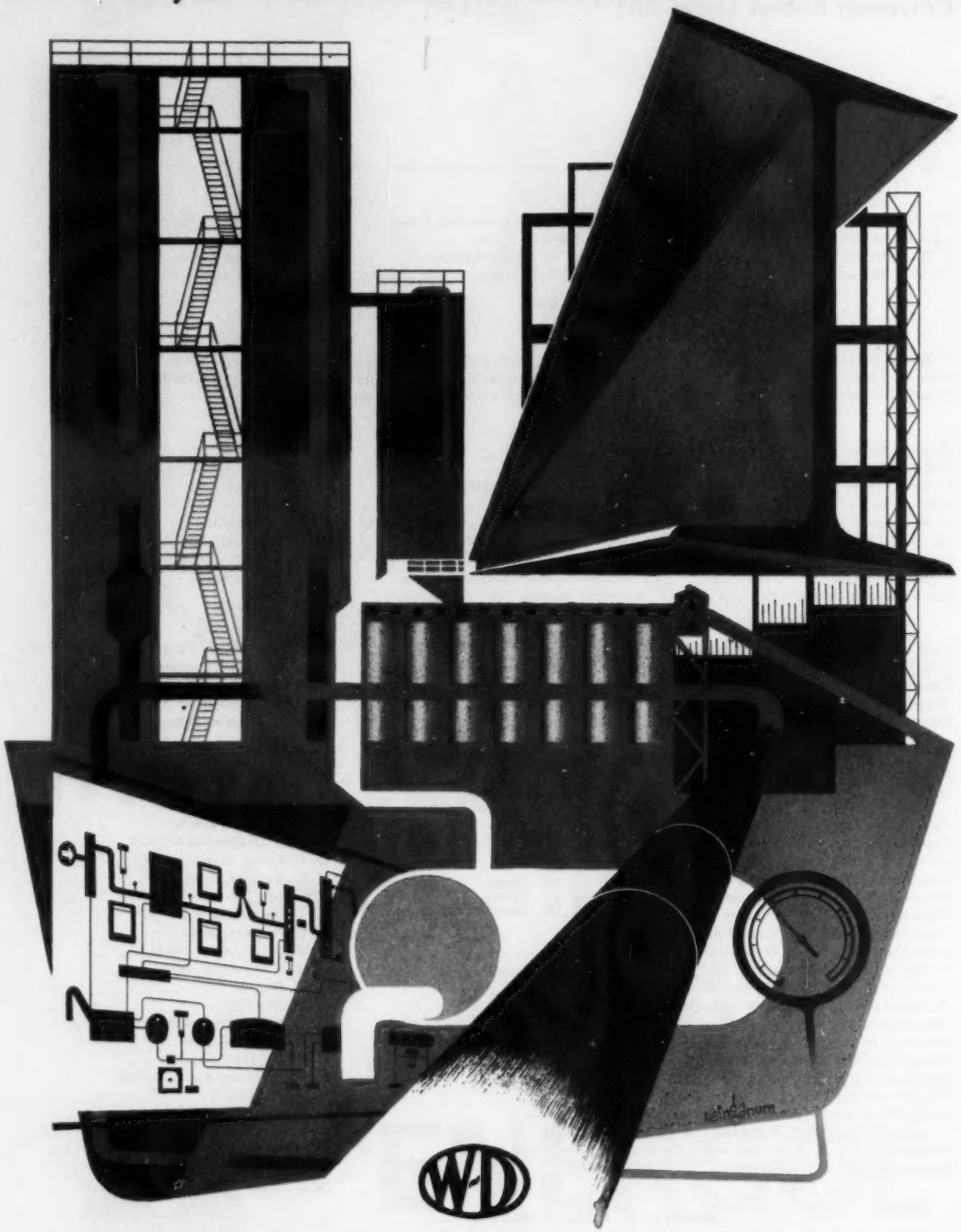

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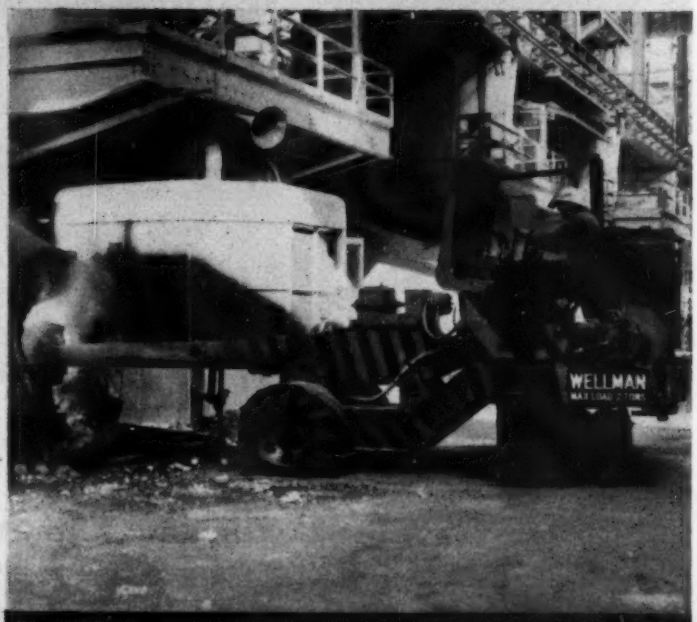

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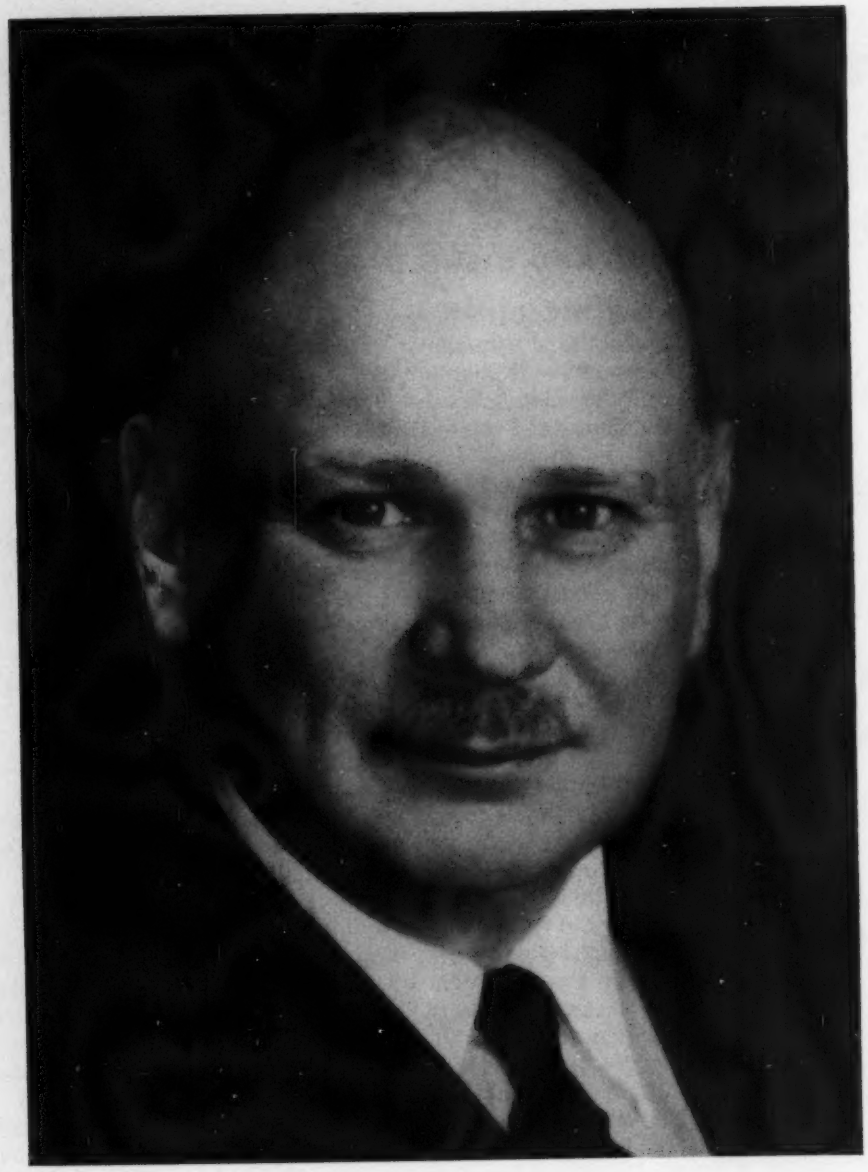
HOWARD BIERS, Dr. mont., Sc.M.

HOWARD BIERS was born in 1904 in New York City. He attended the University of Virginia where he gained a B.Sc. degree, and the Massachusetts Institute of Technology where he was awarded a Sc.M. He also holds the degree of Dr. mont. (Doctor of Mining and Metallurgical Sciences) from the University of Mining and Metallurgy, Leoben, Austria.

Dr Biers joined the Union Carbide and Carbide Research Laboratories, Inc. as a research metallurgist in 1927. From 1930 to 1940 he was a consulting engineer in Paris, Brussels, and London. He then returned to North America to serve as technical advisor to the Metals Controller of the Canadian Government Department of Munitions and Supply. At the same time Dr Biers served as a member of the Government's Technical Advisory Committee, Canadian chairman of the Ferro-alloy Committee of the War Production Board, member for Canada of the joint US-UK-Canadian Metallurgical Mission, and Special Advisor to the Department of Trade and Commerce.

In 1948 Dr Biers rejoined Union Carbide as a consulting engineer. He later became Director of Sales Development of the Union Carbide Ore Company and in 1955 he was appointed Sales Manager of the Alloys and Kemet Division of Union Carbide International Company. In 1959 he was appointed Senior Consultant to Union Carbide International Company.

Dr Biers, a Fellow of The Institution of Metallurgists and a Member of The Institute of Metals, is an Honorary Life Member of the AIME and an Honorary Member of the American Society for Metals. He is an Overseas Honorary Member of the Verein deutscher Eisenhüttenleute, and an Honorary Member of the Société Française de Métallurgie, besides belonging to metallurgical societies and institutes in Belgium , Spain, and Austria. He has been a member of The Iron and Steel Institute since 1933 and was elected an Honorary Member in 1955. This year, in appreciation of his valuable services to the Institute through many years, he has been elected an Honorary Vice-President.



Howard Biers, Dr.mont., Sc.M.
Honorary Vice-President

Report of Council for 1960

THE COUNCIL submit this, their Annual Report and Statement of Accounts for the year 1960, to Members for their approval at the 92nd Annual General Meeting of The Iron and Steel Institute.

The 91st Annual General Meeting and the Autumn General Meeting were held in May and November respectively, and a Special Meeting took place in Italy in May and June.

The Engineers Group held two meetings, in Scunthorpe and London, and the Powder Metallurgy Joint Group organized two meetings in London. Joint meetings were also held with Affiliated Local Societies in steelmaking districts.

ROLL OF THE INSTITUTE

The total membership at 31 December 1960 was 5272, compared with 5204 at the corresponding date in 1959.

During the year 306 Ordinary and 87 Associate Members were elected or reinstated. The deaths of 46 were reported; 180 resigned, 73 were struck off the Roll of Members, and 26 elections lapsed owing to non-payment of subscriptions.

An analysis of the membership at 31 December 1960 is given in Table I, and the membership trend since the foundation of the Institute is shown in Fig.1.

OBITUARY

The Council announce with regret that the following 33 members died during 1960:

BLEGEN, H. (Sauda, Norway)	9 July
BRUCE-GARDNER, Sir Charles, Bt. (London)	1 October
CHEVENARD, P. (Paris, France)	15 August
DEWHURST, W. (Sheffield)	12 February
DICKENSON, J. H. M. (Sale)	Not known
EDWARDS, C. A. (Swansea)	29 March
EYT, E. (Pamiers, Ariège, France)	Not known
FRANCIS, A. V. (Wolverhampton)	22 May
GANDHI, N. P. (Devlali, India)	26 June
GÖRANSSON, K. A. F. (Sandviken, Sweden)	13 June
GRACE, E. G. (Bethlehem, Pa., USA)	25 July
GUNST, P. M. (Amsterdam, Holland)	14 July
HAKER, J. (Johannesburg, South Africa)	3 February
HOOPER, B. (Harrow)	2 September
HYSLOP, R. M. (London)	February
LOFQUIST, K. H. S. (Filipstad, Sweden)	12 September
MURRAY, G. (Cowley)	25 July
PHILLIPS, D. L. (Swansea)	6 October
PROBYN, F. E. C. (Ebbw Vale)	15 October
QUIJANO DE LA COLINA, R. (Madrid, Spain)	20 April
REES, H. T. (Cardiff)	12 August
ROBSON, S. (London)	26 March
SCHNEIDER, C. (Paris, France)	6 August
SHARP, R. (Nottingham)	17 September
SMITH, E. C. (Cleveland, Ohio, USA)	20 May
STURROCK, A. G. (Western Springs, Ill., USA)	1 July
TAYLOR-GILL, A. P. T. (Sheffield)	20 November
TINLEY, E. L. (Wolverhampton)	15 April
TOSH, A. F. (Darlington)	Not known
TURNER, S. B. (Totley)	15 February
UPTON, V. E. (Grindleford)	10 October
WIDDOWSON, J. G. (Sheffield)	20 August
WOOD, G.	14 March

The following 14 Members died earlier than 1960, but their deaths were not reported until later:

AMBERG, K. H. (Stockholm, Sweden)	November 1959
DARDENNE, R. L. (Paris, France)	July 1959
DESCHAMPS, J. M. (Sydney, Australia)	16 October 1959
DOUGLAS, M. (London)	27 December 1959
JACKSON, E. W. (Middlesbrough)	21 November 1958
JOHNSTONE, W. (Glasgow)	22 December 1959
MURRAY, R. C. (Farnborough, Hants)	14 October 1959
MUSSON, F. A. E. (Westcliff-on-Sea)	1959
OWEN-BARNETT, R. A. (Newport, Mon.)	3 December 1959
PEACOCK, J. A. (Scunthorpe)	30 October 1959
PULLEN, R. H. (Port Talbot)	July 1959
RODRIGUEZ DE LA PENA, A. (Reinosa, Spain)	1959
SCHWARZ, C. V. (Milan, Italy)	1 December 1959
STOUGHTON, B. (Bethlehem, Pa., USA)	30 December 1959

Sir Charles Bruce-Gardner, Bt, who joined the Institute in 1910, was President for the year 1955–56. Dr C. A. Edwards, F.R.S., had served as a member of Council from 1937 to 1946. Dr E. G. Grace, who had been a member since 1914, was awarded the Bessemer Gold Medal in 1942.

Mr K. A. F. Göransson, elected in 1926, was a member of the Reception Committee for the Institute's meeting in Sweden in that year, and Monsieur Charles Schneider (elected 1946) was on the Reception Committee which organized the Institute's visit to France in 1956.

The following had been members for more than 40 years: Professor Bradley Stoughton (elected 1903), Mr E. W. Jackson (1904), Señor R. Quijano de la Colina (1912), Mr J. M. Deschamps (1916), Mr J. G. Widdowson (1917), and Professor P. Chevenard (1919).

HONORARY MEMBER OF THE INSTITUTE

At the Annual General Meeting it was announced that the Council had unanimously elected Professore Dott. F. De Carli, President of the Associazione Italiana di Metallurgia, to be an Honorary Member of the Institute.

CHANGES ON THE COUNCIL

President-Elect

At the Autumn Meeting 1960, it was announced that the Council had unanimously decided to nominate Sir Charles Goodeve, O.B.E., D.SC., F.R.S., F.I.M., for election as President at the Annual General Meeting, 1961, to hold office for one year.

Honorary Vice-Presidents

Dott. Ing. G. Falck, Chairman and Managing Director of Acciaierie e Ferriere Lombarde Falck S.p.A. and Professor E. Manuelli, Managing Director of the Finsider Company, were elected Honorary Vice-Presidents in connexion with the Special Meeting in Italy. The election was announced at the Annual General Meeting and the diplomas were presented to them by the President at the Joint Meeting in Milan on 30 May.

Major W. R. Brown, D.S.O., Dr J. W. Jenkin, Mr T. Jolly, and Mr N. H. Rollason were also elected Honorary Vice-Presidents of the Institute.

TABLE I Membership of The Iron and Steel Institute at 31 December 1960 and comparison with 1959

	Membership at 31 December 1960													1959		
	Joint membership with:															
	Ordinary membership		Institute of Metals		Institution of Metallurgists		Both Institute & Institution		Totals		Total membership		Grand totals	Total membership		Grand totals
	Home	O'seas	Home	O'seas	Home	O'seas	Home	O'seas	Home	O'seas	Home	O'seas		Home	O'seas	
Patron	1	...	...	...	...	...	...	...	...	...	1	...	1	1	...	1
Members:																
Hon. Vice-Presidents	8	12	2	1	1	...	2	...	5	1	13	13	26	8	11	19
Hon. Members	1	9	...	1	...	...	1	1	1	2	2	11	13	2	10	12
Non-paying Members	2	3	...	...	...	...	...	...	...	...	2	3	5	3	2	5
Life Members	61	27	4	8	5	...	7	8	16	16	77	43	120	75	45	120
Ordinary Members	1836	991	448	378	564	51	434	62	1446	491	3282	1482	4764	3298	1479	4777
Total (Members)	1909	1042	454	388	570	51	444	71	1468	510	3377	1552	4929	3387	1547	4934
Associate Members	69	22	177	22	27	1	24	1	228	24	297	46	343	240	30	270
Total (both classes)	1978	1064	631	410	597	52	468	72	1696	534	3674	1598	5272	3627	1577	5204

Other changes

Mr W. C. Bell and Professor A. G. Quarrell were elected Vice-Presidents and Mr M. A. Fiennes, Mr N. C. Lake, Mr G. W. Lee, Mr P. M. Thomas, D.S.O., T.D., and Mr H. W. A. Waring, C.M.G., were elected Members of Council.

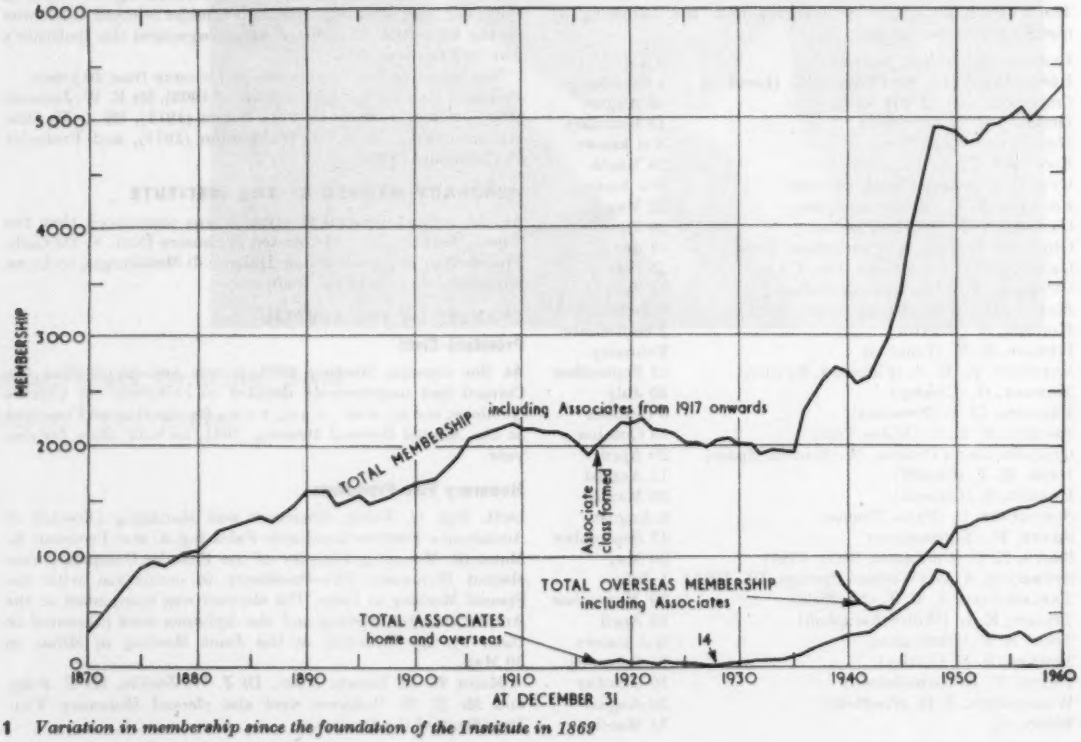
Honorary Members of Council

Sir Ronald Prain, O.B.E., President of The Institute of Metals, agreed to serve as an Honorary Member of Council during his term of office, following Mr G. L. Bailey, C.B.E. Mr J. W. Todd continued in a similar capacity during his presidency of the West of Scotland Iron and Steel Institute.

The following agreed to serve as Honorary Members of Council during their presidencies of the Affiliated Local Societies named:

Mr R. Dingwall (Cleveland Institution of Engineers, following Col. W. H. Mather, O.B.E., T.D.); Mr H. E. Gresham (East Midlands Metallurgical Society, continuing presidency); Mr R. C. Powell (Ebbw Vale Metallurgical Society, following Mr W. B. Williams); Dr E. Simister (Leeds Metallurgical Society, following Mr W. L. Bolton); Mr J. D. Townsend (Lincolnshire Iron and Steel Institute, continuing presidency); Mr R. Cobill (Liverpool Metallurgical Society, following Mr B. Ryan); Mr A. B. Ashton (Manchester Metallurgical Society, following Dr E. F. Emley); Mr H. H. Stanley (Newport and District Metallurgical Society, continuing presidency); Mr S. McLintock (North Wales Metallurgical Society, following Mr H. Edwards); Mr W. C. Heselwood (Sheffield Metallurgical Association, following Professor A. G. Quarrell); Professor R. J. Sarjant, O.B.E., D.SC. (Sheffield Society of Engineers and Metallurgists, following Mr H. Bull); Mr F. V. Wright (Staffordshire Iron and Steel Institute, following Mr L. W. Law); and Mr M. J. A. Thomas (Swansea and District Metallurgical Society, following Mr D. W. Hopkins).

Dr W. O. Alexander and Dr N. P. Allen, F.R.S., succeeded



1 *Variation in membership since the foundation of the Institute in 1869*

Mr E. J. Bradbury and Mr W. E. Bardgett as representatives of The Institution of Metallurgists on the Council.

Continuing the policy of broadening the representation of Members on the Council by electing additional Honorary Members of Council to a maximum of six, the Council invited Professor J. Nutting (Leeds University) and Dr W. S. Walker to serve in this capacity for a period of three years from the Annual General Meeting, 1960.

AWARDS AND PRIZES

The Bessemer Gold Medal for 1960 was presented to Professor Dr Hermann Schenck (Professor of Metallurgy at the Technische Hochschule, Aachen, and since 1950 President of the Verein deutscher Eisenhüttenleute) in recognition of his outstanding contributions to metallurgical research, with special reference to his pioneer investigations into the physical chemistry of steelmaking.

The Sir Robert Hadfield Medal for 1960 was awarded to Dr J. C. Hudson (British Iron and Steel Research Association) in recognition of his long and distinguished work in the field of corrosion of iron and steel.

An *Andrew Carnegie Silver Medal* for 1959 was awarded to Dr P. R. V. Evans (formerly at University College, Swansea, now at the Armour Research Foundation, USA), for a report on 'The effect of rolling unstable austenitic 0·76% carbon steel at 220–300°C' (*Journal*, 1959, vol.191, pp.34–44). His co-author, Professor H. O'Neill, was not eligible.

The *Williams Prize* of £100 for 1959 was presented to Mr I. M. D. Halliday (United Steel Companies Ltd), for his paper on 'Continuous casting at Barrow' (*Journal*, 1959, vol.191, pp.121–163).

Ablett Prizes for 1959 of £100 each were awarded to Mr V. Harrison and Mr V. Stephenson (Dorman Long (Steel) Ltd) for their paper on 'The new medium-section mill at the Cleveland works of Dorman Long (Steel) Ltd' (*Journal*, 1959, vol.192, pp.132–142).

THE MEDAL OF THE IRON AND STEEL INSTITUTE

During the year the Council instituted a new gold medal, to be known as 'The Medal of The Iron and Steel Institute', which is to be presented on special occasions to societies that have, in the opinion of the Council of the Institute, rendered exceptional service to science or industry over a lengthy period.

The first Medal was awarded to the Royal Society in recognition of its unique service to science over a period of 300 years. The presentation was made by The Hon. R. G. Lyttelton, Past-President of the Institute, at the Tercentenary Celebrations of the Royal Society on 18 July 1960.

The second Medal was awarded to the Verein deutscher Eisenhüttenleute on the occasion of the Centenary of the foundation of the Society. Mr W. F. Cartwright (President) presented the Medal at the Annual General Meeting (Eisenhüttentag) in Düsseldorf on 3 November 1960.

ANDREW CARNEGIE RESEARCH GRANTS

During 1960 the following grants were made from the Andrew Carnegie Research Fund:

W. D. Brentnall (Sheffield University, working under Professor A. G. Quarrell): £400 (third grant) for a research on the hydrogen-embrittlement of ultra-high-tensile steels.

T. B. Gibbons (Royal College of Science and Technology, Glasgow, working under Professor E. C. Ellwood): £200 (second grant) for a research on the solubility and activity coefficient of CaS in $CaO–Al_2O_3–SiO_2$.

H. Holdhus (Institute of Metallurgy, Technical University of Norway, Trondheim, working under Professor A. B. Winterbottom): £135 for a research on phase equilibria in iron–silicon alloys near the composition $FeSi_2$. (Travelling scholarship to assist the applicant to carry out part of his work in England under Professor W. Hume-Rothery.)

B. Walker (Birmingham University, working under Dr V. Kondic): £450 for a research on the malleablizing of white cast iron.

MEETINGS

Annual General Meeting 1960

The 91st Annual General Meeting was held from Tuesday to Thursday, 3 to 5 May 1960, at the Royal Commonwealth Society, Northumberland Avenue, London, at Caxton Hall, Westminster, and at Church House, Westminster. Mr W. Barr, O.B.E., the Retiring President, was in the Chair at the start of the meeting; later he was succeeded by Mr W. F. Cartwright, D.L., J.P., the new President.

The Meeting opened with formal business, including the presentation and approval of the Report of Council and Statement of Accounts for 1959, the presentation of Medals and Prizes, and the election of new Members and Associate Members.

The President then announced that the Associazione Italiana di Metallurgia had awarded the Federico Giolitti Steel Medal to Mr W. F. Cartwright. This was only the second time that an award of this medal had been made.

Mr Barr then inducted into the Chair Mr W. F. Cartwright, who delivered his Presidential Address on 'Production control in an integrated iron and steelworks' (*Journal*, 1960, vol.195, June, pp.137–144).

The proceedings of the Meeting appear on pp.377–379 of the *Journal* for August 1960 (vol.195). The discussions on electric-arc steelmaking will be found on pp.454–459 of the December 1960 issue (vol.196) of the *Journal*, and those on wide strip appeared in *Special Report* no.67, published in December 1960.

(For the symposium on the determination of gases in metals *see* below: 'Joint Meetings').

The Members' Dinner was held at Grosvenor House, London W1, on Wednesday 4 May 1960; about 1 500 Members and their guests were present. The toast of *The Iron and Steel Institute and Industry* was proposed by the Rt. Hon. Richard Wood, P.C., M.P., Minister of Power, and the President replied. The health of the guests was proposed by Mr I. L. F. Elliot (Hon. Vice-President of the Institute) and acknowledged by Sir Cyril Musgrave, K.C.B. (Chairman of the Iron and Steel Board).

Autumn General Meeting 1960

The Autumn General Meeting was held on Tuesday and Wednesday, 29 and 30 November 1960, at Church House, Great Smith Street, London SW1. The President, Mr W. F. Cartwright, was in the Chair. The papers discussed dealt with fluid flow in furnaces and converters, and with martensite. The proceedings will be found on pp.269 and 270 of the April 1961 issue of the *Journal*. The discussions have appeared in the following issues of the *Journal*: discussion on martensite, 1961, vol. 198, pp. 165–179; discussion on fluid flow (part), this issue, pp. 290–297, remainder in August 1961 issue.

(For the symposium on steels for reactor pressure circuits *see* below: 'Joint Meeting').

Thirteenth Hatfield Memorial Lecture

By agreement with the Council of Sheffield University, acting on the recommendation of the Lecture Committee, Mr L. Rotherham (Member for Research, Central Electricity Generating Board) was invited to give the 13th Hatfield Memorial Lecture at the Hoare Memorial Hall, Church House, London SW1, on Tuesday evening, 29 November 1960. The subject of the Lecture was 'The contribution of metallurgy to electric power generation'; it is printed in the February 1961 issue of the *Journal*, pp.109–116.

Special Meeting in Italy

At the invitation of the Associazione Italiana di Metallurgia, the Institute held a Joint Meeting with that Association in Milan on 30 and 31 May 1960. This formed part of the Institute's Special Meeting in Italy, which lasted until 11 June. The meeting consisted of three sections: Section I, from 29 May to 3 June in Milan and Genoa; Section II, from 4 to 7 June in Rome; and Section III, from 8 to 11 June, in Naples.

During the Meeting, visits were paid to the following works:

Breda Siderurgica S.p.A., Stabilimenti di San Eustacchio S.p.A. (Brescia), Dalmine S.p.A., Innocenti Società per l'Industria Metallurgica e Meccanica, Acciaierie e Ferriere Lombarde Falck S.p.A., FIAT S.p.A. (Turin), Nazionale Cogne S.p.A. (visited from Milan); Cornigliano S.p.A. and Società Italiana Acciaierie Cornigliano S.p.A. (near Genoa); the Terni Works of the Società per l'Industria e l'Elettricità S.p.A. (visited from Rome); and the Bagnoli Works of Ilva-Altiforni e Acciaierie d'Italia S.p.A. (near Naples).

Members and Ladies were entertained at a reception given by the Lord Mayor of Milan. The Associazione Italiana di Metallurgia were hosts at a banquet in Milan, and Finsider gave a banquet in Rome; Members were also guests at luncheons arranged by the managements of the works in Milan, Turin, Genoa, Terni, and Naples. Some Members and Ladies visited Florence instead of going to Naples with the main party.

The full programme of the meeting was published in the *Journal* for May 1960 (vol.195, pp.13–16), together with a review of the Italian iron and steel industry, prepared by Associazione Industrie Siderurgiche Italiane (pp.16–25). The papers read at the Joint Meeting were printed in the July *Journal*.

Joint Meetings

A meeting on *The determination of gases in metals*, organized by the Society for Analytical Chemistry in conjunction with The Iron and Steel Institute and The Institute of Metals, was held on 3 and 4 May 1960, at the same time as the Institute's Annual General Meeting, at Denison House, London SW1. The papers read and the discussions on them were published as *Special Report* no.68 (1960). Over 400 scientists from all parts of Europe and America attended the meeting.

A symposium on *Steels for reactor pressure circuits* was held immediately after the Institute's Annual General Meeting, in the Hoare Memorial Hall, Church House, London SW1, from 30 November to 2 December 1960; organized by the Institute, it formed part of the programme of the British Nuclear Energy Conference, of which the Institute is a member. The list of papers was printed in the September 1960 *Journal* (p.91) and the papers and discussion will be issued as *Special Report* no.69 (1961). The attendance was nearly 500, a large proportion of which was from overseas.

Iron and Steel Engineers Group

Mr F. B. George continued to serve as Chairman of the Iron and Steel Engineers Group. The Engineering Committee, which superintends the Group's activities, was composed of the following Members as from July 1960:

Chairman
Mr F. B. George

Members

Mr W. S. Atkins	Mr J. A. Kilby
Mr E. H. Booth	Mr N. C. Lake
Mr R. Cox	Mr S. P. Maynard
Mr H. Darnell	Mr J. S. Morton
Mr M. F. Dowding	Mr M. P. Rathbone
Mr R. M. L. Elkan	Mr R. Stewartson
Mr R. J. H. Hunt	Mr N. T. Williams

Ex Officio

Mr W. F. Cartwright	
Sir Julian Pode	Dr H. R. Mills

The Group's first meeting of the year was held in London on 6 and 7 April 1960. The papers, on aspects of the design and operation of plate mills, were printed in the February, March, and April issues of the *Journal* for 1960 and the discussion in the January 1961 issue.

A very successful meeting was held in Scunthorpe from 24 to 27 October 1960. The first two mornings were devoted to technical sessions, with papers on developments at Appleby-Frodingham, lighting in the iron and steel industry, blooming-mill failures, and the redevelopment of an integrated works. Visits were paid to the works of the Appleby-Frodingham Steel Co., John Lysaght's Scunthorpe Works Ltd, and Richard Thomas and Baldwins Ltd, by kind invitation of the managements, who also entertained the Members to lunch. On the evenings of the first two days the Members were the guests of the Lincolnshire Ironmasters' Association at dinner. The programme of the Meeting and the papers are in the October 1960 *Journal*, and the discussion will appear later.

POWDER METALLURGY JOINT GROUP

Two meetings of the Powder Metallurgy Joint Group of The Iron and Steel Institute and The Institute of Metals were held during 1960, both at Church House, London SW1. The first, on 12 April, consisted of a symposium on '*Continuous processing in powder metallurgy*'. The second meeting lasted two days, 15 and 16 December, the first of which was devoted to a symposium on '*Practical aspects of pressing metal powders*', and the second to a number of papers on various aspects.

Two issues, nos.5 and 6, of the Group's publication *Powder Metallurgy* appeared in 1960. Both contained 11 papers, and also the discussions which had taken place at earlier meetings.

BRITISH NUCLEAR ENERGY CONFERENCE

The British Nuclear Energy Conference organized a number of meetings during the year for the discussion of papers on nuclear energy and cognate subjects; these were announced in the News section of the Institute's *Journal*. The Institute, which is a Member of the Conference, invited other Member Institutions to take part in its meeting on steels for reactor pressure circuits held in conjunction with the Autumn meeting. Other meetings devoted to nuclear energy topics were sponsored or organized by the Institution of Mechanical Engineers (four meetings: 2 March, 12 October, 9–10 November, 7 December), The Institute of Metals (8 September), The Institute of Marine Engineers (25 October), and The Institution of Civil Engineers (8 November).

PUBLICATIONS

Journal

The *Journal* was published as usual in 12 monthly parts, forming vols.194, 195, and 196. Indexes and binding cases are being prepared.

Special Reports

Two Special Reports were issued during the year:
No.67 'Production of wide steel strip' (1960)
No.68 'The determination of gases in metals' (1960).

Bibliographies

No bibliographies were published during the year.

List of Members

The List of Members, 1960, containing the names of Members arranged alphabetically and topographically, was published and distributed to all members during the year.

Other Publications

The Institute continued to assist in the publication of the *British Foundryman* until the end of the year and the *Transactions of the Society of Instrument Technology* until the end of May 1960.

JOINT LIBRARY AND INFORMATION DEPARTMENT

The increased use of the loan service of the Joint Library of the Institute and The Institute of Metals, which has been reported over recent years, has continued. During 1960 the number of publications borrowed was 15785, which is higher than in previous years (14871 in 1959, and 14035 in 1958) and is nearly 15% above the total for 1957. The provision to members of photographic copies of documents also continued during the year. A total of 391 textbooks were acquired, a number being gifts. The Council wish to thank those who generously presented books and papers to the Joint Library.

There has been a considerable increase in the holding and utilization by the Joint Library of scientific and technical periodical literature published abroad. This is partly a consequence of the exchange agreements concluded with organizations (notably those in the USSR and the USA) reported in the

previous year. A total of 88 periodicals (including 50 from the USSR) not previously received in the Joint Library have been added to the list of periodicals received. This list was revised during the year and was published in the *Journal* in January 1961.

The larger number of periodicals taken and examined, together with improvements in organization and increased space available in the *Journal*, resulted in a considerable increase in the number of abstracts prepared in the year. The total published in 1960 was about 11400, which is nearly 50% more than in 1959 and in 1958.

As well as being published in the *Journal*, these abstracts have been issued from January 1960 as the 'Abstract and Book Title Index Card Service' (ABTICS). This service provides for sale (on 5in × 3in cards) copies of all abstracts and book titles well in advance of their publication in the *Journal*, where they will continue to appear. The cards contain, in addition, Universal Decimal Classification (UDC) numbers and are sent out fortnightly in batches.

This new service met with a satisfactory response and all the 50 sets of cards produced in 1960 have been distributed to subscribers all over the world, no cards being left in stock. A larger number of sets is being provided in 1961 in view of the demand. Advice and assistance were given to subscribers to enable them to make the best use of these classified abstracts in their information and library departments, including invitations to companies, which resulted in their sending members of their staffs to the Department for short periods of instruction. The Deputy Secretary and the Librarian and Head of the Information Department visited the Centre National de Recherches Métallurgiques (CNRM) at Liège in September 1960, to discuss the use of the abstract cards by member-firms of the Centre; an agreement has since been concluded whereby a central index will be kept in Liège and a number of sets will be used by the firms in Belgium, Luxembourg, and Holland.

The services of the Information Department, like those of the Joint Library, were again much in demand by Members. Public bodies of various kinds also continued to apply for information and advice.

During the year the extensions to the Joint Library were completed, providing additional office accommodation and new storage space. A new floor was laid down in the main reading room, which was fully restored to the use of Members.

Co-operation with The British Iron and Steel Research Association

The friendly co-operation established between the Library and Information Department of the Institute and The British Iron and Steel Research Association has continued during the year and there has been close liaison between the staffs. Special arrangements have been made to enable the best use to be made of the abstracts and a substantial concession of price has been made to member-firms of BISRA who order the abstract cards.

TRANSLATION SERVICES

British Iron and Steel Industry Translation Service (BISITS)

With the continuing support of the steel companies and of BISRA, who between them contributed over two-thirds of the total, 343 translations were issued in 1960, bringing the total since May 1957 to 1155.

As before, just over half the articles were from German. Russian held second place, and there have been new departures such as the translation of 100 pages from a Russian book on creep, and of part of a handbook giving the specifications of Russian steels. The next three languages were French, Czech, and Japanese; three more articles were translated from Chinese during the year.

Co-operation with other translating organizations in this country and the USA has continued to reduce duplication of effort.

An agreement was reached during the year with the Association Européenne pour l'Echange de la Littérature Technique dans le Domaine de la Sidérurgie (ASELT) of the European Coal and Steel Community in Luxembourg for the provision of BISITS translations from the eastern languages to ASELT Members at mutually favourable terms.

Editors of technical journals are also giving BISITS advance information about translations which they intend to publish, and are drawing their readers' attention to selected BISITS translations.

BISRA continues to contribute translations to the Service, notably a number of Russian articles on rolling theory. In addition details of all BISITS translations are published in BISRA *Report Lists* and reprinted by BISITS under the title *Iron and Steel Translations*. In future these will be bi-monthly lists, instead of six-weekly, and the format will be larger. The British Iron and Steel Federation issues a list of new translations as a fortnightly supplement to its *Review of the British and Foreign Press*.

Fortnightly Lists of new translations completed and in preparation are sent out as before, and catalogue cards for BISITS and other translations can be obtained.

The financial position of the Service remains satisfactory. A management fee was again paid by the Service to the Institute.

Stal in English

The arrangement made in 1959 with the Department of Scientific and Industrial Research, whereby the Institute undertook to publish an English-language version of the Russian journal *Stal'*, was continued during 1960, and the September issue (no.9) for the year appeared just before Christmas.

The published price is £20 (plus 12*s* postage) for 12 monthly issues; single copies £2 (plus 1*s* postage). Special rates for Members of The Iron and Steel Institute are £15 (plus 12*s* postage) and £1 10*s* (plus 1*s* postage) respectively.

RELATIONS WITH OTHER SOCIETIES AND ORGANIZATIONS IN THE UK AND OVERSEAS

Throughout the year the Institute has maintained its friendly relations with many scientific and technical societies at home and abroad. Special mention may be made of The Institute of Metals, The Institution of Metallurgists, and the West of Scotland Iron and Steel Institute, and also of the Iron and Steel Board, the British Iron and Steel Federation, and the British Iron and Steel Research Association; co-operation with BISRA is particularly close.

Affiliated Local Societies in the UK

Happy relations between the Institute and the Affiliated Local Societies continued throughout the year. The 13 local bodies affiliated to the Institute are:

Cleveland Institution of Engineers
East Midlands Metallurgical Society
Ebbw Vale Metallurgical Society
Leeds Metallurgical Society
Lincolnshire Iron and Steel Institute
Liverpool Metallurgical Society
Manchester Metallurgical Society
Newport and District Metallurgical Society
North Wales Metallurgical Society
Sheffield Metallurgical Association
Sheffield Society of Engineers and Metallurgists
Staffordshire Iron and Steel Institute
Swansea and District Metallurgical Society.

Joint meetings

The Institute took part in three joint meetings with the Ebbw Vale Metallurgical Society on 18 February, 24 March, and 1 November respectively, the first and last being held jointly with the Engineers Group. On 24 February the Institute held a joint meeting with the Sheffield Metallurgical Association and the Society of Non-Destructive Examination in Sheffield. Besides these special occasions, Members were entitled to attend most ordinary meetings of the Affiliated Societies.

Metallurgical societies overseas

The following 21 overseas societies are 'Kindred' Societies of the Institute:

American Institute of Mining, Metallurgical, and Petroleum Engineers
American Iron and Steel Institute
American Society for Metals
Associação Brasileira de Metais (Brazil)
Association des Ingénieurs Sortis de L'Ecole de Liège (Belgium)
Association Luxembourgeoise des Ingénieurs et Industriels (Luxembourg)
Associazione Italiana di Metallurgia (Italy)
Australian Institute of Metals
Canadian Institute of Mining and Metallurgy
Indian Institute of Metals
Instituto Chileno del Acero (Chile)
Instituto del Hierro y del Acero (Spain)
Jernkontoret (Sweden)
Koninklijk Institut van Ingenieurs (Holland)
Norsk Metallurgisk Selskap (Norway)
Sociedad Argentine de Metales (Argentine)
Société Française de Métallurgie (France)
Société Royale Belge des Ingénieurs et des Industriels (Belgium)
Verein deutscher Eisenhüttenleute (Germany)
Verein Eisenhütte Oesterreich (Austria)
Verein Schweizerischer Maschinen-Industrieller (Switzerland)

Members of the Institute who are members of, or are on the staff of a member firm of, any of the above societies, if resident in the countries concerned, pay reduced membership subscriptions to the Institute. Reciprocal reductions in subscriptions are granted by a number of the kindred societies to Members of the Institute.

CO-OPERATION WITH THE INSTITUTE OF METALS AND THE INSTITUTION OF METALLURGISTS

Joint subscription rates

The Councils of The Iron and Steel Institute, The Institute of Metals, and the Institution of Metallurgists, have agreed on a scheme for joint subscription rates with effect from 1 January 1962. A Joint Consultative Committee has been formed. Details are given in the *Addendum* to this report, *see Journal*, 1961, vol. 198, p. 180.

SIDNEY GILCHRIST THOMAS MEMORIAL

During 1960 further subscriptions to the Sidney Gilchrist Thomas Memorial Fund were received, bringing the total to over £6000; in addition, the Verein deutscher Eisenhüttenleute subscribed DM 50000 on behalf of the German steel industry.

The objects of the Fund are to erect a monument to Sidney Gilchrist Thomas, to award annually a Sidney Gilchrist Thomas Prize to the author(s), of any nationality, of the best paper on basic steelmaking published in the *Journal* during the year, and if funds permit, to award travelling fellowships to candidates in industry under 30 years of age who have completed an advanced course in metallurgy, in order to enable them to study development in steelmaking practice in other countries.

The Monument is an obelisk of polished red granite, with a base and walled-in surround of local blue pennant stone, carrying a bronze head of Thomas in heavy relief and a bronze panel with an inscription recording the achievements of Thomas and his cousin Percy Carlyle Gilchrist. It stands, by kind permission of Messrs Daniel Doncaster and Sons, Ltd, and Messrs Pickford Holland and Co. Ltd, the present owners of the site, in the garden of the Coity House, of the old Blaenavon Company, close to the building where Thomas and Gilchrist carried out their experiments in 1877–78 and in view of the site where the Bessemer shop once stood. It was unveiled by Mr G. H. Latham, LL.D., President of the Newport and District Metallurgical Society, and an Honorary Vice-President of The Iron and Steel Institute, in the presence of a large gathering of leading steelmakers, including the President, the Honorary Treasurer, some Members of the Council, and the Secretary of the Institute. Supporting Mr Latham were the Chairman, Honorary Secretary, and Honorary Treasurer of the Newport Society, the Chairman of the Monmouthshire County Council and the Blaenavon Council, and representatives of the Iron and Steel Trades Confederation; the Transport and General Workers Union, the National Museum of Wales, University College, Cardiff, the Newport College of Technology, and the South Wales Institute of Engineers were represented. The two companies owning the site were represented by their Chairmen and several members of the Boards of Directors.

REPRESENTATIVES AT MEETINGS AND MEMBERSHIP OF MISSIONS OVERSEAS

The Hon. R. G. Lyttelton (Past-President) represented the Institute at the centenary celebrations of The Royal Institution of Naval Architects held in London from 17 to 20 May 1960, and at the tercentenary celebrations of The Royal Society held in London from 18 to 26 July 1960.

At the 75th anniversary of the Société Belge des Ingénieurs et des Industriels, held in Brussels on 21 to 24 June 1960, Monsieur P. van der Rest (Honorary Vice-President) represented the Institute.

The President, Honorary Treasurer, Members of Council, and the Secretary attended the Centenary Celebrations of the Verein deutscher Eisenhüttenleute held in Düsseldorf on 3 and 4 November 1960. Dr K. Adenauer, the Federal Chancellor, honoured the Verein by being present.

EDUCATION

Joint Committee for National Certificates in Metallurgy

The Institute was represented on this Committee by Dr J. W. Jenkin and the Secretary. Changes were made in the organization of the Committee whereby the Ministry of Education assumed responsibility for financing and administering the scheme for National Certificates in Metallurgy (England and Wales) from 1961 onwards; subscriptions to the Prize Fund would, however, continue to be paid by the four metallurgical societies which join in operating the scheme (The Iron and Steel Institute, The Institution of Mining and Metallurgy, The Institute of Metals, and The Institution of Metallurgists).

Sheffield University: Institute Prize 1960

The Iron and Steel Institute Prize of 10*gns* for 1960 was awarded to Mr Neil J. Cavaghan, who had received the Degree of Bachelor of Metallurgy with Honours, and had been recommended by the University as the most suitable recipient of the Prize.

WORSHIPFUL COMPANY OF BLACKSMITHS

The Council nominated Mr R. K. Pratt for admission to the Freedom and Livery of the Worshipful Company of Blacksmiths, under the arrangement whereby the Council is privileged to put forward annually two applications from Members of the Institute for admission to the Company at reduced fees. Members wishing to avail themselves of this concession should communicate in the first instance with the Secretary of the Institute.

HONOURS CONFERRED UPON MEMBERS

The Council offer their congratulations to the following members who have received Honours during the year:

O.B.E. Mr H. R. Rowbotham
Mr F. H. Saniter (Vice-President)

FINANCE

The accounts for 1960 are appended. (In the comment below, figures for the previous year are printed in brackets for comparison).

GENERAL FUND

Balance Sheet and Income and Expenditure Account

The balance sheet at 31 December 1960, and the Income and Expenditure Account for the year ending on that date are submitted in the usual form. Ordinary income £132101 (£108182), exceeded ordinary expenditure £128466 (£111006) by £3635 (deficit £2924).

After taking in certain special items, the sum of £4206, excess of income over expenditure (previous year deficit of £2350) was transferred to the accumulated fund.

THE IRON AND STEEL INSTITUTE

BALANCE SHEET, 31 DECEMBER 1960

General account

1959		LIABILITIES	£	£	£	1959	ASSETS	£	£
		Accumulated Fund			—		*Furniture and Fittings* Not valued		—
34 453		Balance per Account annexed		38 101	3 422		*Motor Cars at Written Down Value*		2 338
					22 502		*Investments at Cost per Schedule*		22 502
		Current Liabilities and Provisions					(Market Value at 31 December £16 408)		
25 916		Sundry Creditors (part estimated)	23 694				*Current Assets*		
54		Due to Sir Robert Hadfield Medal Fund	59			3 960	Stock of Paper as valued by the Managing Editor ...	1 719	
3		Due to Bessemer Medal Fund	11			36 106	Sundry Debtors	38 535	
—		Due to Williams Prize Fund	14			2 459	Deposits and Payments in Advance	2 112	
143		Ablett Prize Fund Account	42			682	Balances at Banks and Cash in Hand	561	
790		Subscriptions received in advance	371		43 207				42 927
5 596		Payments received in advance for Publications	5 991		4 021		Due from House Fund		7 512
		Sundry Provisions as at 31 December 1959:							
3 500		Reserve for Supplementing Staff Pensions	3 500				*Activities in Connexion with Publications*		
1 879		Bank Overdraft	5 326		—		Expenditure incurred in advance on Publications ...		3 331
37 881				39 008					
818		Special Publications Suspense Account		1 501					
73 152				78 610	73 152				78 610

Special funds

		House Fund					*House Fund*		
57 450		Amount received from Companies	58 200			46 626	Lease at Cost *less* amount written off, per Account annexed	46 851	
750		Amount receivable in 1959	—			290	Sundry Debtor	—	
						18 861	Investments at cost, per Schedule	18 861	
58 200			58 200				(Market Value at 31 December 1960 £16 430)		
3 556		Sundry Creditors	—		65 777				65 712
4 021		Due to General Fund	7 512						
65 777				65 712					
£138 929				£144 322	£138 929				£144 322

We have examined the above Balance Sheet of the Institute and found it to be correct.

(*Signed*) W. B. KEEN & Co.
Chartered Accountants

FINSBURY CIRCUS HOUSE
BLOMFIELD STREET
LONDON, EC2

18 March 1961

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1960

EXPENDITURE

1959 £	£		£	£
		Staff Expenses		
46 492		Salaries and National Insurance	49 166	
3 512		Staff Superannuation Fund and Pension	7 133	
2 006		Cost of Staff Luncheon Vouchers	2 103	
52 010				58 402
		Administrative Expenses		
2 644		Printing and Stationery	3 007	
1 254		Postage and Receipt Stamps	1 885	
3 756		Travelling and Entertainment	4 047	
2 550		Meetings	3 517	
1 239		Telephone and Telegrams	1 459	
314		Insurance	339	
250		Audit Fee 1959	250	
660		Sundry Payments	905	
12 667				15 409
		Establishment Expenses		
400		Rent	400	
1 653		Rates and Water	1 794	
2 580		Cleaning, Heating, and Lighting	2 877	
301		Repairs and Decorations	1 799	
444		Office Furniture and Fittings	932	
5 378				7 802
		Activities in connexion with Publications (excluding Salaries and Overhead Charges)		
35 075		1960 Journal—Printing, Paper, etc.	39 911	
3 590		Other Activities—Expenses	3 972	
38 665			43 883	
53		Adjustments—Amounts over-provided in previous year ...	277	
38 718				43 606
		Library and Information Department		
676		Library Books and Binding	1 268	
820		Abstractors' and Reviewers' Fees	1 183	
1 496				2 451
		Miscellaneous		
241		Contributions to Affiliated Local Societies	233	
230		Joint Committee for National Certificates in Metallurgy ...	250	
10		Prizes	10	
—		Medals	152	
256		Grants	151	796
737				
—				128 466
—		Balance carried down		3 635
£111 006				£132 101
2 924		Excess of Expenditure over Income brought down ...		—
—		Balance—Excess of Income over Expenditure for the year		4 206
£2 924				£4 206

INCOME

1959 £	£		£	£
		Subscriptions		
17 464		Current	21 551	
1 231		Arrears	597	
18 695				22 148
		Payments for Services		
9 935		British Iron and Steel Research Association	12 500	
150		Andrew Carnegie Research Fund	—	
250		Mond Nickel Fellowship Committee	250	
2 750		British Iron and Steel Industry Translation Service ...	3 000	
13 085				15 750
1 104		*Interest on Investments (gross)*		704
4		*Deposit Accounts—Interest*		6
		Institute of Metals		
1 000		Library		1 125
1 481		*Rents Received*		1 000
6		*Sundry Receipts*		5
		Activities in connexion with Publications		
57 520		1960 Journal—Revenue	72 838	
15 187		Other Activities—Revenue	18 379	
72 707				91 217
—		Abstracts and Book Title Cards Service		146
2 924		Balance carried down		—
£111 006				£132 101
201		Refund of Superannuation Contributions		257
373		Surplus on Meeting in Middlesbrough		—
—		Surplus on Meeting in Italy		314
—		Excess of Income over Expenditure brought down ...		3 635
2 350		Excess of Expenditure over Income		—
£2 924				£4 206

ACCUMULATED FUND, 31 DECEMBER 1960

1250		Transfer to Reserve for House Fund		1250	33815	Balance at 31 December 1959	34453
2350		Excess of Expenditure over Income for the year		—	—	Excess of Income over Expenditure for the Year ...	4206
34453		Balance carried to Balance Sheet		38101	101	Life Composition Fees received in 1960	192
					1637	Profit on Sale of Funding Stock	—
					2500	Amount received from Insurance Company in Respect of Fire Loss	—
					—	Refund of Superannuation Contribution on Change of Scheme	500
£38053				£39351	£38053		£39351

HOUSE FUND—COST OF LEASE ACCOUNT

		Lease at Cost including Legal Expenses		43518		Amounts written off:	to 31 Dec. 1959	Current Year	Total
		Surveyor's Fees		460		Transfer from Accumulated Fund ...	7250	1250	8500
		Cost of Alterations to Library		579		Bank Deposit Interest	121	—	121
		Cost of Extensions during 1959		13114		Interest on Investment	3674	757	4431
		Cost of Extensions during 1960		2232			11045	2007	13052
						Balance as per Balance Sheet			46851
				£59903					£59903

ANDREW CARNEGIE RESEARCH FUND

BALANCE SHEET, 31 DECEMBER 1960

		LIABILITIES				ASSETS		
		Amount of Original Fund $100000		21241	34670	*Investments at Cost as per Schedule*		34670
25837		*Add:* Amount capitalized per last Balance Sheet		4596		(Market value 31 December 1960 £29648)		
				25837		*Balance at Bank*		
		Sundry Creditors			11	On Deposit Account	11	
	1123	Grants	1240		153	Post Office Savings Bank	157	
	15	Audit Fee	16		164			168
	312	The Iron and Steel Institute—Current Account	149		326	Sundry Debtor—Income Tax recoverable		487
	309	Bank Overdraft	620					
1759				2025				
		Reserve for Travelling Scholarships						
		Balance at 31 December 1959	2600					
2600		Less Grant paid during year	83					
				2517				
		Accumulated Fund						
4964		Balance per Account annexed		4946				
£35160				£35325	£35160			£35325

ACCUMULATED FUND, 31 DECEMBER 1960

1080		Grants		1450	4796	Balance at 31 December 1959		4964
150		Contribution to General Fund on account of Salaries ...		—		Income for the year ended 31 December 1960:		
16		Audit Fee		16	1448	Interest on Investments (gross)	1448	
4		Medal		4	4	Interest on Deposits	4	
34		Legal Charges on Appointment of New Trustees		—	1452			1452
4964		Balance carried forward		4946				
£6248				£6416	£6248			£6416

WILLIAMS PRIZE FUND

BALANCE SHEET, 31 DECEMBER 1960

1959 £	LIABILITIES	£	£	1959 £	ASSETS	£	£
	Capital Value representing Market Value of £3 000 3½% Conversion Loan on 21 September 1926 when the Fund was inaugurated			2 769	*Investments at Cost per Schedule* (Market Value at 31 December 1960 £2 146)		2 769
2 220			2 200		*Balance at Bank*		
10	*Sundry Creditors*—The Iron and Steel Institute		—	38	On Current Account		15
601	*Accumulated Fund*—Balance per Account annexed		625	24	*Sundry Debtors*		
					Income Tax Recoverable	47	
					Iron and Steel Institute	14	
							61
£2 831			£2 845	£2 831			£2 845

ACCUMULATED FUND, 31 DECEMBER 1960

100	Awards		100	586	Balance 31 December 1959		601
10	Legal Charges *re* appointment of new Trustees		—		*Income for the year ended 31 December 1960*		
601	Balance carried forward		625	121	Interest on 3½% Conversion Loan	121	
				4	Interest on Defence Bonds	3	
				125			124
£711			£725	£711			£725

BESSEMER MEDAL FUND

BALANCE SHEET, 31 DECEMBER 1960

	LIABILITIES				ASSETS		
400	*Capital Value* representing Market Value £400 4% Debenture of the L. & N.W. Railway	400			*Investments:*		
500	*Grant* from The Iron and Steel Institute	500		400	£474 15*s.* 0*d.* British Transport 3% Guaranteed Stock 1978/88	400	
900			900	500	£500 4% Funding Stock 1960/90 (Market Value 31 December 1960 £724)	500	
3	Accumulated Fund—Balance per Annexed Account		11	900			900
				3	*Sundry Debtor*—The Iron and Steel Institute		11
£903			£911	£903			£911

ACCUMULATED FUND, 31 DECEMBER 1960

26	Medal		26	50	Balance at 31 December 1959		3
80	Diplomas		—		*Income for the year ended 31 December 1960*		
3	Balance carried forward		11	14	Interest on British Transport Stock	14	
				20	Interest on 4% Funding Stock	20	
				34			34
				25	Grant from The Iron and Steel Institute		—
£109			£37	£109			£37

£109

SIR ROBERT HADFIELD MEDAL FUND

BALANCE SHEET, 31 DECEMBER 1960

	LIABILITIES			ASSETS	
268	*Capital Value* representing Market Value of £267 11*s.* 2*d.* 3% Savings Bonds 1955/65	268	268	£267 11*s.* 2*d.* 3% *Savings Bonds 1955/65* ... ... (Market Value at 31 December 1960 £241)	268
54	Accumulated Fund—Balance per Account annexed ...	59	54	Sundry Debtor—The Iron and Steel Institute	59
£322		£327	£322		£327

ACCUMULATED FUND, 31 DECEMBER 1960

3	Medal	3	49	Balance at 31 December 1959	54
54	Balance carried forward	59		Income for the year ended 31 December 1960:	
			8	Interest on 3% Savings Bonds	8
£57		£62	£57		£62

THE IRON AND STEEL INSTITUTE

SCHEDULE OF INVESTMENTS AT 31 DECEMBER 1960 SHOWING NOMINAL VALUES, COST, AND PRESENT DAY VALUES

Nominal Value £ s. d.	Nature of Security	Market Value, 31.12.60 £	Cost Value £
General funds of the Institute			
2197 7 0	3½% War Stock	1302	2161
1324 7 4	3½% Conversion Loan	1124	1254
2954 19 0	4% Funding Loan 1960/90	1942	3176
42 19 3	4% Funding Loan 1960/90	37	32
2000 0 0	3% Savings Bonds 1955/65	1800	2000
5000 0 0	3% Savings Bonds 1955/65	4500	4972
2000 0 0	3% Savings Bonds 1960/70	1582	2000
1500 0 0	3% Savings Bonds 1965/75	1172	1500
4854 2 0	British Transport 3% Guaranteed Stock 1978/88	2949	5407
		£16408	£22502
House Fund			
10000 0 0	4% Funding Stock 1960/90	8738	10131
3200 0 0	4% Funding Stock 1960/90	2796	3251
2200 0 0	4% Funding Stock 1960/90	1924	2030
681 13 0	4% Funding Stock 1960/90	595	600
196 10 1	4% Funding Stock 1960/90	171	231
587 13 10	3½% Conversion Loan	498	513
205 15 6	3½% War Stock	122	212
2615 11 2	British Transport 3% Guaranteed Stock 1978/88	1586	1893
		£16430	£18861
Andrew Carnegie Research Fund			
(Trustees: The Hon. R. G. Lyttelton, N. H. Rollason, and W. F. Gilbertson)			
6897 14 11	3½% War Stock	4807	6896
800 0 0	3½% War Stock	474	794
2963 12 0	3½% Conversion Loan	1756	2007
1793 15 0	British Electricity 3% Guaranteed Stock 1968/73	1327	1762
4166 18 7	4% Funding Stock 1960/90	3640	4676
500 0 0	4½% Defence Bonds (Conversion Issue)	500	500
17812 10 3	British Transport 3% Guaranteed Stock 1978/88	10654	10863
1000 0 0	3% Savings Bonds 1955/65	900	1000
2250 0 0	3% Savings Bonds 1960/70	1768	2250
3803 0 0	5½% Exchequer Stock 1966	3822	3922
		£29648	£34670
Williams Prize Fund			
(Trustees: The Hon. R. G. Lyttelton, N. H. Rollason, and W. F. Gilbertson)			
3452 15 7	3½% Conversion Loan	2046	2670
100 0 0	3½% Defence Bond (Conversion Issue)	100	99
		£2146	£2769
Sir Robert Hadfield Medal Fund			
267 11 2	3% Savings Bonds 1955/65	£241	£268
Bessemer Medal Fund			
(Trustees: Desmond Lysaght, The Hon. R. G. Lyttelton, and N. H. Rollason)			
474 15 0	British Transport 3% Guaranteed Stock 1978/88	285	
500 0 0	4% Funding Stock 1960/90	439	500
		£724	£500

(*Signed*) E. JULIAN PODE, *Hon. Treasurer*
K. HEADLAM-MORLEY, *Secretary*

We have examined the foregoing Balance Sheets and Income and Expenditure Accounts with the Books and Vouchers of the Institute and certify them to be correct. We have also verified the balances at the Bankers and the Securities for the Investments shown above.

(*Signed*) W. B. KEEN & Co., *Chartered Accountants*
FINSBURY CIRCUS HOUSE, BLOMFIELD STREET, EC2
16 March 1961

The balance of the accumulated fund credited to the balance sheet was £38101 (£34453). Additional cost of extensions during the year at the Institute's offices at no.4 Grosvenor Gardens, £2232, has been charged to the House Fund—Cost of Lease Account. The total amount written off the value of the lease which runs for 60 years from September 1955 is £13052 (£11045) and its value in the balance sheet is now £31505 (£33512). The total amount received by the House Fund is £58200 (£58200).

TRUST FUNDS

The accounts of the Andrew Carnegie Research, Williams Prize, Bessemer Medal, and Sir Robert Hadfield Medal Funds, are presented as usual.

INVESTMENTS

Investments are valued in the balance sheets at their cost when purchased.

In the case of the General and House Funds the cost was £41363 (£41363) and their market value at 31 December 1960, was £32838 (£34580). In the case of the four trust funds the cost was £38607* (£38607) and their market value at 31 December 1960 was £32759 (£34747).

An Addendum to the Report of Council, entitled 'Co-operation with sister institutions', was published on p. 180 of the June issue of the Journal.

* This figure includes £474 15*s* 0*d* British Transport 3% Guaranteed Stock 1978–88 at a figure of £400 and which is included in the balance sheet of the Bessemer Medal Fund.

Recent and forthcoming Special Reports

Production of wide steel strip

Special Report 67, which was reviewed in the May 1961 issue of the *Journal*, reports the symposium which formed part of the Institute's Annual General Meeting 1960. The report is a quarto volume of 196 pages with 98 line diagrams and 57 photographs. Copies may be obtained, price £3 5*s* 0*d* each (postage 1*s*) from the Secretary.

The determination of gases in metals

Special Report 68 is a report of the highly successful joint meeting of The Society for Analytical Chemistry, together with The Iron and Steel Institute and The Institute of Metals, in May 1960. A full review was given in the June 1961 issue of the *Journal*. The report is octavo format, 316 pages and 8 plates, with numerous line diagrams. The price is £3 3*s* 0*d* (postage 1*s*) from the Secretary.

Steels for reactor pressure circuits

To be published in August, Special Report 69 contains the 26 papers and discussions presented at the symposium organized by The Iron and Steel Institute for the British Nuclear Energy Conference, in London last November–December. Further details will be given in the August issue of the *Journal*.

Structural processes in creep

It is hoped to publish towards the end of this year the papers and discussions presented at the joint meeting of The Iron and Steel Institute and The Institute of Metals in London, May 1961. This will be no.70 in the Institute's Special Report series, and full details will be given later.

STAL *in English*

Number 4 (April 1961) of the cover-to-cover translation of the Russian journal *Stal'* will be published this month. Full details of subscriptions to *Stal in English* are available from the Secretary of The Iron and Steel Institute.

Report of the Annual General Meeting 1961

The Ninety-second Annual General Meeting of The Iron and Steel Institute was held on Wednesday and Thursday, 3 and 4 May 1961, at The Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1. Mr W. F. Cartwright, D.L., J.P., *the Retiring President, was in the Chair at the beginning of the Meeting, his place being taken later by Sir Charles Goodeve,* O.B.E., D.SC., F.R.S., *the new President.*

Minutes of previous Meeting

The minutes of the Autumn General Meeting held in London on 29 November 1960 were taken as read, and were confirmed and signed.

Welcome to Members and visitors

The **President,** on behalf of the Council, welcomed the Members and visitors who were present, and especially those from overseas. He referred in particular to the visitors from Italy. All those who had attended the meeting in Italy the previous year had very happy memories of the visit and they were therefore delighted to see their Italian friends present, including Dr Vincenzo Ventafridda, Dr Giuseppe Testero, and Dr Giovanni Lo Pinto, members of the committee which had made the arrangements.

Among Honorary Vice-Presidents present were Mr Gunnar Schjelderup from Norway, Mr Evert Wijkander from Sweden, Mr Berndt Gronblom from Finland, and Dr Josef Oberegger from Austria. Professor Dr Hermann Schenck from Germany, Bessemer Gold Medallist in 1960, and two other Bessemer Medallists, both from Sweden, Dr Magnus Tigerschiöld and Professor Bo Kalling were also at the meeting.

Kindred organizations in other countries were well represented: Dr Howard Biers, an Honorary Member of the Institute, was representing the American Institute of Mining, Metallurgical, and Petroleum Engineers, Professor A. G. Lefebvre represented the Société Royal Belge des Ingénieurs et des Industriels, and Monsieur A. Sourdillon the Société Française de Métallurgie.

They were also particularly pleased to see a number of friends from the USA, and Dr N. N. Timoshenko and his colleagues from the Soviet Union.

Obituary

The **President** announced the names of Members whose deaths had been reported. The names of those whose deaths had been reported during 1960 were given in the Report of Council, and the names of those who had died before the Autumn General Meeting 1960 but had not been previously reported, and of those who had died since the Autumn General Meeting 1960, were given in the agenda of the present meeting.

The President referred in particular to Mr W. J. Dawson, C.B.E., a Member of Council for many years, an Honorary Vice-President, and Bessemer Gold Medallist in 1948; Monsieur Léopold Bouvier, former head of ARBED, an Honorary Vice-President; Monsieur Maurice de Wendel, a Member since 1909; and Señor R. Quijano de la Colina, a Member since 1912.

The Meeting stood in silence as a token of respect.

Honorary Treasurership

The **President** said that Sir Julian Pode had expressed the desire to cease being Honorary Treasurer. Sir Julian was now President-Elect of the British Iron and Steel Federation. He had served the Institute well since he had taken office in May 1959; in those two years he had piloted through a complete revision of salary and pension arrangements for the staff and instigated a thorough review of accounting procedure.

Sir Julian's successor would be announced before the next meeting.

Presentation of Report of Council and Accounts

The **President** then presented the Report of Council for 1960 and the Statement of Accounts (this issue, pp.229–241) and moved their adoption.

The Report of Council showed that the preceding year had been a good one. The membership had continued to increase. A wide range of interesting papers had been published in the *Journal*, and papers were now being published much more promptly than used to be the case.

The English translation of the Russian periodical *Stal'* which the Institute prepared by agreement with the Department of Scientific and Industrial Research, was being published within four months after publication in Russia. This was a very good journal, and he strongly recommended it to Members.

The Translation Service had continued its activities and had produced at remarkably low cost about 350 translations of articles in many languages, from Chinese, Czech, Polish, and Russian, as well as from Western European languages.

The new Abstract Card Service had been well received. Over 11 000 abstracts had been published during the previous year, making the Institute's service probably the largest in the western world dealing with iron and steel technology and related subjects.

The Engineers Group and the Powder Metallurgy Joint Group had held good meetings. He thanked the two Committees and especially Mr F. B. George, Chairman of the Engineers Group, and Mr D. A. Oliver, C.B.E., Deputy Chairman of the Powder Metallurgy Joint Group. Secretarial and publishing work for the Powder Metallurgy Group had been carried out efficiently by The Institute of Metals, thanks to the personal interest of Lt-Col S. C. Guillan, Secretary of The Institute of Metals. He had just retired after 50 years service with the Institute, and the President offered him the best wishes of The Iron and Steel Institute.

The Council had decided in 1960 to found a new gold medal to be known as 'The Medal of The Iron and Steel Institute', to commemorate the Tercentenary of the Royal Society. The first medal had been awarded to the Royal Society, and he had presented the second to Professor Schenck during the centenary celebrations of the Verein deutscher Eisenhüttenleute in Düsseldorf in November 1960.

The outstanding event of his year as President had been the meeting in Italy. This had been very pleasant socially as well as being full of technical interest. The Italian steel industry had made enormous advances and was still advancing rapidly. The Council were most grateful to all those who had taken such trouble on behalf of the Members of the Institute.

Co-operation with The Institute of Metals and The Institution of Metallurgists had undergone a considerable change during the year. A circular sent to all Members the previous month explained the arrangements agreed with the Councils of The Institute of Metals and The Institution of Metallurgists. The objects were to ensure close collaboration between the three societies, and to ensure that metallurgists received services similar to those provided by the engineering and other professional institutions. Although this would cost the Institute a little money the Council was convinced that the agreed policy was in the best interests of the membership of

the Institute as a whole as well as of metallurgists. About 1200 of the Institute's Members were already members of The Institution of Metallurgists; he urged others who were qualified to join the Institution but had not applied for membership to do so without delay. They would help to raise the status of the profession and to strengthen the connexion between the societies.

The Council greatly valued the continued co-operation of the British Iron and Steel Research Association, the British Iron and Steel Federation, and the many kindred societies overseas, as well as the constant help from the Affiliated Local Societies in this country.

He also paid tribute to the excellent work of the permanent staff of the Institute during his year of office.

The **Honorary Treasurer** (Sir Julian Pode) seconded the motion. He said that the accounts for the year ended 31 December 1960 were presented in the usual form. Expenditure was £128466, nearly £17500 more than in the previous year. This was largely due to an increase in salaries, a larger staff, and the cost of the new superannuation fund, and also to an increase in the size and cost of the *Journal* and to a general increase in activities.

The income, at £132101, had been £21195 higher than in the previous year, the chief factors being an increase of £3453 in subscriptions and of £18510 in activities in connexion with publications. After taking into account certain special items, the excess of income over expenditure transferred to the Accumulated Fund had been £4206.

It was interesting to note that income from Members' subscriptions averaged about £4 4*s*. 0*d*. per Member, but the expenditure incurred amounted to about £24 10*s*. 0*d*. per Member.

The motion for the adoption of the Report of Council and the Statement of Accounts was carried unanimously.

Presentations

Bessemer Gold Medal

The **President** announced that the Bessemer Gold Medal for 1961 had been awarded to Mr W. Barr, O.B.E. (Colvilles Ltd) in recognition of his outstanding work in the development of weldable high-tensile steels for the engineering and shipbuilding industries.

Mr Barr's research work had become famous all over the world. He was the sort of person for whom the medal was really intended, because he was a creative metallurgist.

The President then presented the Bessemer Gold Medal to Mr Barr.

Mr **W. Barr,** in reply, expressed his appreciation of the great honour that the Institute had conferred upon him. He was proud to join the ranks of the Bessemer Medallists, and was particularly happy that so many earlier recipients were among the audience, including his own Chairman, Sir Andrew McCance, F.R.S., who had had so great an influence on his own career.

The Sir Robert Hadfield Medal

The **President** announced that the Sir Robert Hadfield Medal for 1961 had been awarded to Mr Emrys Davies (Brymbo Steel Works Ltd) in recognition of his outstanding work in the field of pre-refining of blast-furnace metal and subsequent use in either electric or open-hearth furnaces.

The President then presented the award to Mr Davies who expressed his great appreciation of the honour that had been conferred upon him, and upon Brymbo. The work had been done there over many years, and he gratefully acknowledged the assistance of many colleagues and collaborators.

Andrew Carnegie Silver Medal

The **President** presented the Andrew Carnegie Silver Medal for 1960 to Dr K. A. Salmon of The University of Sheffield, for a report on 'The kinetics of sulphur transfer from iron to slag' (*JISI*, 1960, **196,** 393–403). His co-author, Dr R. G. Ward, was not eligible for the award.

Williams Prizes

The **President** presented Williams Prizes for 1960 of £50 each to Mr T. McHugh and Mr F. A. Kirk (Low Moor Fine Steels Ltd) for a paper on 'Some aspects of steel extrusion' (*JISI*, 1960, **194,** 423–434). Their co-author, Mr R. Cox, was not eligible for an award.

The **President** presented Williams Prizes for 1960 of £50 each to Mr J. Chapman (Steel, Peech and Tozer) and Mr W. Montgomery (Round Oak Steel Works Ltd) for a paper on 'The effect of flow distribution on air preheat in the open-hearth furnace' (*JISI*, 1960, **196,** 15–28).

Ablett Prize for 1960 of £100

The **President** announced this award had been deferred.

Announcements

Election of Honorary Vice-Presidents

The **President** announced that the Council had elected two prominent members of the Institute to be Honorary Vice-Presidents. They were Dr Howard Biers of the United States of America, and Dr T. P. Colclough, C.B.E.

The President said that Dr Colclough had been a Member of the Institute since 1921 and a Bessemer Gold Medallist in 1954. He had given tremendous services to the iron and steel industry of this country and to the Institute over a very long period of time.

Dr Biers had become a Member in 1933 and had been elected an Honorary Member in 1955. They were indebted to him for the great interest he had shown in the work of the Institute, and especially for his ready advice on all matters to do with the USA.

After the President had presented the certificates, Dr Biers replied briefly, thanking the President and Council for the honour conferred on him.

Election of additional Honorary Members of Council

The **President** said that three years ago the Council had decided to elect not more than six additional Honorary Members of Council in order to strengthen the representation of different interests on the Council. He thanked Dr L. F. C. Northcott for serving during the last three years. Mr R. W. Evans had been asked to serve for a further period, and Sir Robert Shone, Executive Member of the Iron and Steel Board, had been invited to join the Council.

Special Meeting in the USA and Canada from 19 October 1961

The preliminary circular about the Institute's visit to America had already been distributed. The programme was excellent, and the meeting was clearly going to be exceptionally interesting. They were most grateful to all the friends in the USA who were taking an active part in making the arrangements. Registrations had come in very well; the party would substantially exceed 200 members and ladies.

Special Meeting in Germany 1962

The Verein deutscher Eisenhüttenleute had sent the Institute a very cordial invitation to hold a meeting in Düsseldorf in the summer of 1962, and this had been accepted with pleasure.

Affiliation of West of England Metallurgical Society

The Council was pleased to announce that arrangements had been made for the West of England Metallurgical Society, a society which had been founded a few years ago, to become affiliated to the Institute.

Retiring Members of Council In accordance with Bye-law 10, the names of the following Vice-Presidents and Members of Council had been announced at the Autumn General Meeting 1959 as being due to retire at the present Annual Meeting:

Vice-Presidents: Mr E. T. Judge, Mr F. H. Saniter, O.B.E., and Dr C. Sykes, C.B.E., F.R.S.

Members of Council: Mr R. A. Hacking, O.B.E., Mr E. W. Colbeck, Lt-Cdr G. W. Wells, Mr T. R. Craig, O.B.E., and Mr P. E. Holloway.

No other Members having been nominated up to one month previous to the present meeting, the retiring Vice-Presidents and Members of Council were presented for re-election.

Changes on the Council since the last General Meeting on 29 November 1960:

Member of Council: Mr H. W. A. Waring, C.M.G.

Honorary Members of Council:

Professor H. O'Neill, President of The Institute of Metals, to succeed Sir Ronald Prain, O.B.E.

Mr F. R. Brace, President of the Liverpool Metallurgical Society, to succeed Mr R. Cobill

Mr J. E. Russell, President of the Sheffield Metallurgical Association, to succeed Mr W. C. Heselwood

Mr F. H. Saniter, O.B.E., President of the Sheffield Society of Engineers and Metallurgists, to succeed Professor R. J. Sarjant. (Mr Saniter is a Vice-President of the Institute.)

Mr G. H. Moore, President of the West of England Metallurgical Society.

Dates of Meetings

The **Secretary** gave the dates of forthcoming meetings:

Autumn General Meeting, London, 29 and 30 November 1961, followed by *Engineers Group Meeting*, London, 1 December 1961.

Annual General Meeting, London, 2 and 3 May 1962.

Autumn General Meeting, London, 28 and 29 November, 1962.

14th Hatfield Memorial Lecture, by Dr Morris Cohen (USA), Sheffield, 10 May 1962, and *15th Hatfield Memorial Lecture*, by Professor A. G. Quarrell (Sheffield) during the Autumn General Meeting 1962, in London.

Andrew Carnegie Scholarships

The **Secretary** said there had been no awards since the previous General Meeting.

Election of Members

The scrutineers reported that all the candidates for membership had been duly elected.

Members

Abhyankar, Pandurang Raghunath (Kirkee, Poona 3, India); **Agarwal,** Gopal P., M.S.(MET.) (Pittsburgh, Pa, USA); **Alford,** M. H. T. (Vorarlberg, Austria); **Armfield,** George Frederick (London); **Aspland,** Reginald Charles David, B.SC.(ENG.), A.M.I.MECH.E., M.INST.F. (London); **Becht,** Edward F., S.B., M.S. (Latrobe, Pa, USA); **Bell,** Albert Edward (Workington); **Benjamin,** Paul, PH.D., A.R.C.S.T., A.INST.F. (Bonnybridge); **Bilby,** B.A., B.A., PH.D. (Sheffield); **Blackmore,** Brian Francis, B.SC.(ENG.) (Port Talbot); **Blythe,** Leslie Raymond (Port Talbot); **Boyce,** Henry Paul, B.SC.(MECH.ENG.), A.M.I.MECH.E. (Port Talbot); **Boyes,** Stewart Rees, A.M.I.MECH.E. (Port Talbot); **Breese,** Paul (Irlam); **Brooks,** Philip George, B.A. (HONS.) (Port Talbot); **Broom,** Trevor, M.A., PH.D. (Leatherhead); **Broomfield,** Geoffrey Hugh, L.I.M. (Harwell); **Brunton,** Richard Scott (Port Talbot); **Bruzzone,** Giorgio (Milan, Italy); **Cairns,** John Harper, M.SC.TECH., PH.D., A.M.C.S.T., A.I.M. (Leeds); **Charles,** James Anthony, B.SC., A.R.S.M., A.M.I.M.M., A.I.M. (Cambridge); **Chatterjee,** S., B.SC. (London); **Chouvel,** René (Firminy (Loire), France); **Christie,** Samuel, A.M.I.PROD.E. (Bellshill); **Clarke,** Anthony, A.I.M. (Luton); **Clayton,** Fred, B.MET. (Irlam); **Comley,** Robert John (Port Talbot); **Cox,** Wilfred Henry (Port Talbot); **Dale,** Ronald N., A.M.I.MECH.E. (Port Talbot); **Davison,** Jack, B.SC., A.I.M.M. (Normanby); **Davies,** John Henry, A.M.I.E.E. (Port Talbot); **de Vries,** Hendrik (Amsterdam, Holland); **Druart,** Herman (Marchinelle, Belgium); **Dulis,** E. J. (Pittsburgh, Pa, USA); **Dwek,** Maurice Désiré, B.SC. (ENG.), A.M.I.E.E. (Port Talbot); **Edwards,** John Kenneth, M.A., A.M.I.E.E. (Port Talbot); **Elan,** Meir (Haifa, Israel); **Evans,** G. E., B.SC., A.M.I.E.E. (Port Talbot); **Evans,** John (Port Talbot); **Ferguson,** Duncan (Glasgow); **Fernandez,** Santiago O., M.S.MET., B.S.(MECH. ENG.) (Pittsburgh, Pa, USA); **Findlay,** Joseph Cyril (Loudwater); **Fujiwara,** Tadayoshi, D.SC. (Tokyo, Japan); **Geiszler,** A. R., B.SC. (London); **Godwin,** Roy Sidney, L.I.M. (Copper Cliff, Ontario, Canada); **Granier,** Maurice, LT CDR (Indret (Loire Atlantique), France); **Gregory,** H. T., ASSOC.I.E.E. (Port Talbot); **Griffiths,** John A. (Manchester); **Gutierrez,** Oscar Garcia (Gijón, Spain); **Hale,** Walter Malcolm (Port Talbot); **Harris,** Howell David (Port Talbot); **Hedley,** George Graham (Greenford); **Hewitt,** Ewan Christian, M.A., G.I.MECH.E. (Sheffield); **Hicks,** Thomas Owen (Port Talbot); **Higgin,** Charles Sidney (London); **Hodge,** Dennis, A.M.INST.MARINE E. (London); **Holmes,** Frank, A.M.I.MECH.E., A.M.I.PLANT.E. (Port Talbot); **Holst,** Wilhelm, DR.TECHN. (Oslo, Norway); **Howard,** William Aubrey, M.INST.F. (Port Talbot); **Ige,** Joseph Austen, B.SC.(HONS.), A.M.I.MECH.E. (Stockton-on-Tees); **Jenkins,** Kenneth Ronald (Port Talbot); **Jones,** John Hugh (Port Talbot); **Jones,** Lionel John Seddon (London); **Kirchhof,** Elizabeth H., B.A. (Bridgeville, Pa, USA); **Knight,** George Allen, A.MET., F.I.M. (Wellington); **Krishnamurthi,** Srinivasan (Durgapur, W. Bengal, India); **Lemingwell,** W. Bruce, B.SC. (Sharon, Pa, USA); **Lewis,** Lt-Col Richard George, T.D. (Birmingham); **Lewis,** William George Melville (Port Talbot); **Lima e Silva,** Armenio de (João Monlevade-Minas, Brazil); **Lloyd,** D. A. (Port Talbot); **Lockerbie,** John (Consett); **Mackay,** Ian A., A.M.I.MECH.E., M.INST.F. (Newcastle-upon-Tyne); **Mackey,** Sean, B.SC., PH.D., A.M.INST.C.E., M.I.STRUCT.E. (Hong Kong); **Mackrill,** John Edward (Port Talbot); **Maclean,** Ian Kenneth (Irlam); **Markowicz,** Jan Henryr, A.I.M. (Dagenham); **Mason,** David Fenton (Port Talbot); **Miche,** Paul Georges (Port Talbot); **Miller,** David H., B.S. (Pittsburgh, Pa, USA); **Miller,** David John, A.M.I.MECH.E. (London); **Mitchell,** Dennis Walter, B.SC.(ENG.), A.R.S.M., A.M.I.M.M. (Rotherham); **Monsen,** John Robert, B.SC. (London); **Montgomery,** James Campbell Pollock (London); **Moore,** John C., A.I.M. (Swindon); **Morgan,** Charles Randall, A.M.I.MECH.E., M.I.PLANT.E. (Port Talbot); **Morgan,** Robert Frederic Jenkin, A.M.I.MECH.E. (Ebbw Vale); **Morton,** Ronald J., B.S. (Duluth, Minnesota, USA); **Moses,** David Puntan, B.SC.HONS.(MET.), A.I.M. (Morriston); **Mothersele,** Dennis W. (Port Talbot); **Murphy,** William J., B.S., M.S., PH.D. (Monroeville, Pa, USA); **Murray,** Graham Francis James, B.SC., M.I.MECH.E., A.M.INST.C.E., F.INST.F. (London); **Mustoe,** Douglas Howard, ASSOC.E.I.E., A.M.INST.F. (Port Talbot); **Neal,** Harry, M.I.E.E. (London); **Needham,** William James, G.I MECH.E., A.M.I.PLANT.E., A.INST.F. (Port Talbot); **Newton,** Cyril (Corby); **Nicholson,** David Vadim (London); **Ogden,** John Henry (Port Talbot); **O'Hanlon,** John, M.A.(HONS.), (Normanby); **Okamoto,** Masazo, DR.ENG. (Tokyo, Japan); **Oldham,** William Johnston (Wednesbury); **Oliver,** John Philip, A.M.I.MECH.E. (Port Talbot); **Orr,** Jack Barry, B.ENG.(HONS.), A.M.I.MECH.E. (Rotherham); **Oswald,** John Wheen, B.SC., A.M.I.E.E. (Newport); **Oviatt,** James Frederick (Port Talbot); **Panchal,** Popatlal Ishvarlal, M.SC., B.S. (MET.ENG.) (Pittsburgh, Pa, USA); **Pillans,** Stuart (Cardiff); **Planner,** Bernard P., ENG.D. (The Hague, Holland); **Pringle,** John (Nottingham); **Ramachandran,** Sundaresan, SC.D. (Brackenridge, Pa, USA); **Reid,** William Henry (London); **Rice,** Frank Clements, (Port Talbot) **Ryan,** Charles Francis, M.B.E., B.A.(ENG.), A.M.I.MECH.E. (Rotherham); **Salisbury,** William George, M.A., A.I.M. (Sheffield); **Sawyer,** David Myles (London); **Schmit,** René (Luxembourg); **Shnay,** Robert C. (Toronto, Ontario, Canada); **Shore,** Lewis Thomas (Newport); **Sillavan,** Christopher James (Manchester); **Sillavan,** John David (Manchester); **Sims,** Walter H. R. (Bolton); **Smart,** Peter Denzil, B.SC., A.M.I.E.E. (Port Talbot); **Smallwood,** Maurice, A.M.I.MECH.E., M.INST.F. (Port Talbot); **Smith,** Herbert Charles, A.M.I.MECH.E. (Port Talbot); **Smith,** William Elliot, B.SC.(ENG.), A.M.INST.C.E. (Peterborough); **Squires,** Arthur M., PH.D. (New York, NY, USA); **Stansfield,** William Alan (Bradford); **Stark,** Thomas Wilson (Bellshill); **Stein,** Ronald C. (Bonnybridge); **Strandell,** P. Olof (Stockholm, Sweden); **Strong,** John, M.A. (London); **Tarrant,** Russell Thomas (Rotherham); **Thomas,** David Bowen (Port Talbot); **Thomas,** David Gurwyn (Port Talbot); **Thomas,** Enos William, A.M.I.MECH.E. (Port Talbot); **Thomas,** Gilbert Wootton, B.A. (Port Talbot); **Thompson,** Kenneth Dixon (Port Talbot); **Tolsen,** Roger Martin Ward, B.A. (Manchester); **Topping,** C. G. A. (Port Talbot); **Venturello,** Giovanni (Turin, Italy); **Watkins,** Frank James, M.INST.C.E., M.I.STRUCT.E. (London); **Watkins,** Peter Glyn, A.M.I.MECH.E. (Sheffield); **Watts,** Stanley A., A.M.I.E.E. (Nottingham); **Waugh,** Anthony Lawrence, A.I.M. (London); **Weston,** Frederick Charles (Port Talbot); **Williams,** Basil V., GRAD.I.MECH.E. (Port Talbot); **Williams,** Derek Bule, B.SC., A.M.I.MECH.E. (Port Talbot); **Williams,** Joseph Edward (Port Talbot); **Williams,** William Malcolm, M.SC., PH.D., A.INST.P. (Montreal, Canada); **Wilson,** Harold Munro, B.SC., A.M.I.MECH.E., A.M.I.E.E. (Bonnybridge); **Winterkamp,** Hans, DIPL.ING. (Bremen, Germany); **Woodhead,** Jack Harper, B.MET.(HONS.) (Sheffield); **Wordsworth,** Christopher (Port Talbot); **Worner,** John, A.M.I.MECH.E. (Port Talbot).

Associate Members

Bam, Edul Pheroze, B.SC.(ENG.) (London); **Bulmer,** George Brian (West Hartlepool); **Coleman,** Christopher Edward (Newcastle-upon-Tyne); **Czoch,** Kazimierz Zygmunt (London); **Das,** Anil Kumar (Dist-Burdwan, W. Bengal, India); **Ede,** H. (Chesterfield); **Farag,** Mahmoud Mohamed (Sheffield); **Fletcher,** Gordon (Newcaste-upon-Tyne); **Ganpule,** Ashok Anant (London); **Handisyde,** Paul (Cambridge); **Hepburn,** Ian Roy, B.SC.TECH. (HONS.) (Oxford); **Hitchon,** John William Francis, B.E. (Saint Germain-en-Laye, (S & O.), France); **Howard,** Richard Antony, B.SC., A.R.S.M. (Cardiff), **Hunns,** David Walter Housden, L.I.M. (Colnbrook); **Kim,** Sung Soo (Seoul, Korea); **Mitko,** Andrzej (London); **Mohanty,** Amitav Banares, India); **Murthy,** Anantharaju Srinivasa (Durgapur, India); **Parbat,** Rabindra Nath (London); **Paterson,** Leonard John, B.SC.(HONS.), A.R.C.S.T. (Glasgow); **Percival,** Maurice Arthur (Coventry); **Peters,** Robert James Wallace, B.SC., A.R.C.S.T. (Glasgow); **Price,** David Richard William (Bilston); **Ray,** Sachchidananda (London); **Rayner,** David, A.M.C.S.T., L.I.M. (Sheffield); **Richmond,** Colin, L.I.M. (West Hartlepool); **Rickett,** Keith Baker (Scunthorpe); **Robinson,** Neville, B.MET.(HONS.) (Consett); **Rogers,** Alan Hadcroft (Manchester); **Sastri,** Aiyaswami Suryanarayan (London); **Sathgurunath,** V. A. (Durgapur, India); **Schofield,** Brian, L.I.M., A.M.C.S.T. (Manchester); **Siddell,** Derreck (Consett); **Singh,** Manjit (Varanasi,

India); **Singh,** Ran Vijay (Sheffield); **Smith,** David Granville (Portsmouth); **Summerton,** John Michael, B.SC., PH.D., A.I.M. (Birmingham) **Stephenson,** Edwin David (Newcastle-upon-Tyne); **Stevens,** Michael John, L.I.M. (Langley); **Tomlinson,** Stanley Frederick (Bilston); **Trotter,** Harold George, B.SC.(HONS.MET.) (Cardiff); **Vincent,** A. V., B.A. (Workington); **Webb,** Charles William (Cannock); **Webster,** Peter, B.SC. (Sheffield); **Willoughby,** Arthur Frank Wesley (London).

The **President** declared the applicants duly elected, and said that they numbered 154 Members and 45 Associate Members; the total membership of the Institute was now 5266.

Induction of new President

Mr W. F. Cartwright, D.L., J.P., the retiring President, next inducted the new President, Sir Charles Goodeve, O.B.E., D.SC., F.R.S., into the chair. He said that Sir Charles, since he had joined the industry 15 years ago, had made a tremendous impact on it. Under his leadership, BISRA had become a potent force in every part of the iron and steel industry. The Institute would be fortunate in having as its President someone with such consuming energy and enthusiasm.

Vote of thanks to the retiring President

The **President** (Sir Charles Goodeve), in proposing the vote of thanks to Mr Cartwright, spoke of his superb leadership of the Institute. He had occupied the Presidency not only with great dignity, but also great humanity. He was a progressive steelworks engineer with an enormous thirst for ideas. It would be true to say that Mr Cartwright had set the pace of technical progress in the industry.

Presidential address

The **President** then delivered his address, 'Steel in an expanding Britain' (*JISI*, 1961, **198**, June, 117–123).

A vote of thanks to the President for his address was proposed by Mr C. R. Wheeler, C.B.E. (Past-President) and carried with acclamation.

Technical sessions

A number of papers were presented and discussed at the technical sessions on both days of the Meeting. Details were given in the April issue of the *Journal* (p.324). Some of the papers have already been published in the *Journal*; the remaining papers and the discussions will be published later.

Speeches at the Annual Dinner

The Annual Dinner of The Iron and Steel Institute was held at Grosvenor House, Park Lane, London W1 on Wednesday, 3 May 1961, when about 1500 members and guests were present. The President, Sir Charles Goodeve, O.B.E.,F.R.S., was in the chair. There were three speakers.

Sir Howard Florey

Sir Howard Florey, President, The Royal Society, in proposing the toast 'The Iron and Steel Institute and Industry' said: 'It is most unusual for somebody from the biological sciences to propose the toast of The Iron and Steel Institute and the steel industry. Therefore I am particularly glad to have been given the honour tonight; but of course it raises one or two little matters, the principal one being what in fact I shall say. Probably all of you know that one of the necessary qualifications for a person who is a professor is to be able to speak at frequent intervals for an hour without saying very much. I am a fully qualified professor. (*Laughter*)

'But I realized that would not get me very far in a field about which I know absolutely nothing and in front of such a critical audience as The Iron and Steel Institute. So I had to run over a few points, and my mind wandered a little and I wondered whether there was anything that I, as a pathologist, had in common with you who deal with astronomical amounts of the metal which is said to be an indicator of the degree of civilization of the country. Then it occurred to me that I should have the happy experience of addressing a company that had been well fed and had imbibed sufficient alcohol to reduce its inhibitions somewhat, so that the most trivial things would seem funny and in fact the company would be in a jolly mood and be fit for anything. (*Laughter*)

'It also occurred to me that another of the pharmacological effects of alcohol might be manifest, and that some of our faces might be redder than usual due to the presence in them of plenty of haemoglobin. So I was reminded that none of us would be here to partake of this magnificent feast if it had not been for this iron-containing pigment which is circulating at high velocity in our blood vessels at this very moment, carrying, I trust, an adequate supply of oxygen to our vital centres to burn up the excessive number of calories which we have just ingested. (*Laughter*) I followed this trend of thought slightly by thinking how peculiar it is that it is relatively difficult to get iron into our bodies. For some reason iron does not seem to want to go into the tissues, but once it is there, the body hangs on to it very tightly, and in fact we lose very little of this element once we have absorbed it. Then I wondered whether there might be some parallel between the difficulty of getting iron into our bodies and the difficulty of getting exports out of the country. (*Laughter*) But, fortunately for you, I saw no future in this possible analogy. Anyway you are not interested in the trivial amounts of iron involved in biological systems, for even if all of us in this room were smelted down with the most modern techniques, we would only supply enough iron to make a few paper clips. (*Laughter*) I thought you would permit me to mention these few facts in the hope that you will find an extra interest in the element with which you deal in millions of tons.

'Your President and your Secretary very kindly provided me with what is commonly called "background information", and I have tried to thread my way through the complexities of the bodies dealing with the interests of iron and steel. To an outsider the organization seems to be a typical British product, composed of sections which co-operate in ways which are somewhat obscure, but which must be very efficient judging by the flourishing state of the steel industry.

'Of course, one of the main functions of the Institute and the British Iron and Steel Research Association is to bring before you all the advances in technical procedures associated with your great industry. There has been a recent report* on the

* 'Development in the iron and steel industry'; Iron and Steel Board Special Report, 1961, London, HMSO.

steel industry from which I gather that great stress is laid upon the importance of technical progress as a major feature of the development plan for the future, which envisages no rise in the industry's present labour force but an increase in efficiency. We hear a great deal about technology these days and how it has been inadequately cultivated in this country for the best part of this century. That is absolutely true; but times are changing, and very considerable efforts are being made to rectify this position. In scientific circles it is very respectable indeed now to be an engineer. (*Laughter*) Of course, metallurgy has always enjoyed a great reputation. In fact, its reputation is so high that they demolished my house in Oxford to build a new metallurgical department.

'We have to be careful in these days how we use words, and I am not sure that the word "technologist" is going to connote much longer the highly trained people who look after and nourish our great industries, for I was surprised the other day to read that a butcher is now described as a "meat technologist", and I suppose before long we shall have egg technologists, horticultural technologists, and so on. Perhaps this is one of the subtle workings of democracy. But there is no doubt that if the country wishes to maintain and to improve its material standards of living, it will have to pursue science and technology with more vigour than at present, and of course science and technology are based on education, using that word in a wide sense.

'I think we all must have been astonished when Russia first put an object into orbit round the earth. We were probably less astonished when she put a man into orbit the other day, but we should have been staggered that this great technological feat was accomplished by a nation which only a generation or two ago was largely illiterate. Russia, we are told, has put education before everything else, including science, and we ignore this at our peril. I think one of the disquieting facts about the reporting in this country of the Russian feat has been the attribution of extravagant praise to the man who inhabited the capsule. Do not let it be supposed that I do not admire his bravery very highly. I do not decry that at all; nor should it be supposed that I do not admire his exceptionally well balanced central nervous system. But judged on the basis of zoological progression, he is a super mouse, a super dog, or, better still, a super monkey. The exploit was, in fact, a product of technology, and Russian technology is based in the last analysis on education in the schools, and on what must be an admirable training in metallurgy, physics and the rest, which go to make the background to the mechanical arts. So you will understand me when I say I wish I had seen more evidence in our daily newspapers, which form and mould public opinion, that it was realized that Russian technical achievements depend on training, and that her political power depends on her technological achievement. (*Applause*)

'There is an uneasy feeling among some of us who actually teach, that in spite of the great efforts that are now being made in the country, we are still failing to make the best use of the splendid human material which we have at our disposal. It is clear that a country such as this has only limited resources and cannot possibly do everything; but one of the problems that confront us at present is to know what the priorities are, how we are to allot them, and how we are to put the right emphasis on development. It is possible that we are doing far too little in the biological sciences, for it has rightly been pointed out that some of the major problems in the world in the next decade or so may well be of a biological nature. What, for example, shall we do about the rapidly increasing population, especially in the tropics? Nor is the steel industry exempt from problems of a physiological and psychological nature. It is a measure of the intellectual grasp of your President that he was able to put in my hands a sheet of paper indicating the problems of this nature which he knows exist in your great industry. For example, there are the hot conditions of work, the design of steel smelters' goggles, the design of seats for crane cabs and rolling mills, detection of carbon monoxide, the study of absence and accident records in a medium-size steelworks, and the study of absence and accident records in a medium-size engineering works. I am sure that the President knows a great deal about these matters, and it is in line with his wartime record, for I have had the pleasure of reading during the last week or two a book describing his activities in what were known as the "Wheezers and Dodgers". Obviously he is a man of great resource not easily beaten down by bureaucrats!

'During the war he collected around him a remarkable group of eccentric characters and contributed strikingly in unconventional ways to the war effort. Perhaps one of the most important aspects of his wartime activities was his involvement in operational research, which is now so important in many phases of industry. In him you have a man thoroughly imbued with the idea of doing experiments, and I feel that my being asked to speak tonight is in the tradition of the "Wheezers and Dodgers", and I am merely one more datum in his scheme of operational research. (*Laughter*) Be that as it may, I am sure that with him as your President, The Iron and Steel Institute and the Research Association of which he is the head will have a most prosperous and happy year.

'You will all be relieved to know that my veiled threat to lecture for an hour will not materialize, and now I have pleasure in proposing the toast of The Iron and Steel Institute and Industry coupled with the name of your distinguished President.' (*Prolonged applause*)

Sir Charles Goodeve

The President replied, and proposed the toast of the guests. He said: 'I am sure you would like me to begin by thanking Sir Howard Florey for coming here this evening and so ably proposing the toast of our Institute and industry. (*Applause*) I think we were all very much impressed by the particular point he made about the odd way in which we have reacted to this enormous and magnificent feat of the Russians, and our failure to analyse that to its core. We appreciate that extremely important point. We also appreciate the very humerous yet telling way in which he made the remainder of his speech. We in the steel industry, Sir Howard, are really rather proud of the industry and the part that science has played in it. Its part is of course an important one because we feel the necessity of keeping this country always prominent in its important place in this world.

'You, Sir Howard, have come here as a stranger to our industry but not to the world. As most of you know, there are hundreds of thousands, if not millions, of people living today entirely as a result of the discovery of penicillin, a very large part of which came from Sir Howard Florey's researches. (*Applause*) That was perhaps the most outstanding but not his only contribution to medical science. I have a personal feeling of friendliness towards him because he is the second 'colonial' who has become president of the premier scientific society, the Royal Society. The first was, of course, Lord Rutherford who came from New Zealand, and Sir Howard Florey comes from Australia. (*Applause*) We are very pleased to see him supported by His Excellency the High Commissioner for Australia, Sir Eric Harrison. (*Applause*) I have always looked upon Sir

Eric as a past master of after dinner stories and I have a few of his stories in my book!

'This method of science to which Sir Howard has referred is a powerful set of tools, and one of those tools is the meticulous way in which scientists record the results of their experiments. To illustrate this, an incident occurred the other day in Burlington House. A Fellow of the Royal Society was coming out of the portals of that great institution when he found waiting for him a Royal Academician who accosted him with the question "Do you know a lady by the name of Mary Smith?" The Fellow of the Royal Society produced his pocket book, turned over the pages until he found the letter *S*, referred to it, and said "Yes". The Academician then said "Did you take her home last Friday night?" Again the Fellow produced his pocket book and turned up the appropriate page and said "Yes". Then the Academician said "Well, she is my wife and I do not like it". The Fellow of the Royal Society again brought out his pocket book, turned up the appropriate page, referred to it carefully and replied "Neither did I"! (*Laughter*) There are quite a few people – and this might have come from Sir Eric – who think that F.R.S. stands for "Fond of Rude Stories"!

'Again, Sir Howard, I should like to say how much we appreciate your coming here tonight and entertaining us so ably.

'In view of the special sessions of The Iron and Steel Institute today and tomorrow on computers as applied to the iron and steel industry, it was natural that I should turn again to "Peggy", the BISRA computer; but I should have known better, because Peggy, true to her sex, is very temperamental. In a few well chosen mathematical terms she told me to go and jump in a quadratic! (*Laughter*) As far as I could gather, she was very upset about the bits that I left out of the speech the last time she prepared one for me! These were some rather awkward things about some members of the Council of The Iron and Steel Institute! Between you and me we have been having a lot of trouble with Peggy these last few years, because she will insist on giving logical answers to questions without first finding out whether the answers are acceptable to the people she gives them to! (*Laughter*) For instance, she is regularly pointing out that it is some years since the threat of nationalization disappeared from the steel industry. Therefore it should be time for us to have a little healthy criticism of our industry for a change, which was completely suppressed during that period of threatened nationalization. We should point out that it is 22 years since there was any unemployment in this country, and we still think in the terms of our social and political organizations as if unemployment is just around the corner.

'On the whole, as you will have learned from the sessions this afternoon, the computers in our iron and steel industry are rather well behaved. They are now making rapid strides towards helping not only in the simple problems, but in some of the complex problems facing our managements. It is probably known to you that the computer can now predict the likely outcome of a game of chess or of cards. It is a very short step from that to predicting the outcome of a strike! Assuming for a moment – and I hope it is a good assumption – we do not have strikes for the fun of it, you can see that we have in our hands an automatic substitute for strikes. This is a serious point, and I would not mind suggesting that within five years we shall be able to carry out the operation if only by putting the trade union officials on one side and the management on the other, and playing out the strike through the computer, speeding it up about a hundred times so that it came down to about five or six minutes. We could perhaps stretch it out a little longer because it would not be much fun, and make it up to an hour or so! (*Laughter*) Or we could of course go further and through linear programming remove the causes of strikes entirely. You can see what a wonderful thing this could be if we could remove this black spot on our otherwise clear claim to being civilized.

'When in Spain recently my wife and I came across a gipsy who was warming his shirt in front of the fire. On asking him what he was doing that for, he replied that he was toasting the visitors! (*Laughter*) That is the second part of my job this evening, but despite the warmth of our feeling towards our visitors, I think I should try to use something a little more gentle!

'I think all of us accept that a party without guests is a pretty poor party indeed, and we are grateful to all the visitors for gracing our table this evening. In toasting their health I suppose we are thinking of their future health. We shall assume that they are all right at the present time. The variety of our guests rather reflects something of the place which the iron and steel industry occupies in the world. The biggest number of our guests are, of course, customers. We have customers galore! I am not sure if that is the right adjective. They must be in a very happy mood tonight because there is plenty of steel about, the quality of course is absolutely superb, and the prices are right! (*Laughter*) Above all, most of them will have seen the recently published report, to which Sir Howard referred, including the plans of the steel industry for the future. The steel industry has put out its plans in a blue book. It has actually been put out by the Iron and Steel Board, which is a short title for the Iron and Steel Industry's Publicity and Planning Department! (*Laughter*) Those of you who have read it know about this very positive plan for growth. So that when in a moment we are toasting our guests, we are wishing them not only good health for personal reasons, but we are also wishing them courage themselves to plan for growth.

'Most of our many visitors who have come from abroad have been referred to in earlier remarks on one of the other occasions associated with this annual meeting of the Institute, and therefore I do not propose, with their agreement, to repeat many of these. But I should like to mention the German Ambassador who has done us the courtesy of coming here this evening, and to tell him what friendly respect we have for our elder sister society, the Verein deutscher Eisenhüttenleute, which is nine years older than we are, and has been one of our closest friends through all our 91 years of life. (*Applause*) I think we should also like to extend a special welcome to His Excellency the High Commissioner for Pakistan. We wish him success in getting a first-class steelworks going in his country. (*Applause*) We have another Ambassador present, Dr van Kleffens, Ambassador of the European Coal and Steel Community. We welcome him personally and also as a symbol of our hope that some time in the future this contact with Europe through him and the Community will grow into a much closer association throughout the whole of our trade. I think that the only exception to this wish is a newspaper run by a fellow Canadian! (*Laughter*)

'I should like to make a quick reference to Mr H. S. Wingate, President of the International Nickel Company of Canada. I shall not tell any stories about him, but I hope to have an opportunity later in the year of meeting him and I shall save them until then.

'In this group I should like to refer to one of our Russian colleagues who has managed to be with us tonight. He is Dr Timoshenko from Moscow. (*Applause*) We in the steel industry take pride in the fact that the Russians have chosen our metal for their curtain purposes! (*Laughter*)

'There are many other guests: the House of Commons, Services, sister institutions, other scientific associates, research associations, and the chairmen and managing directors of companies. Many of these really are only pseudo-guests who are part of the Institute but are here as guests because they cannot afford to pay for their dinner! (*Laughter*)

'I must single out three members for special mention. The first is our newest Bessemer Medallist, Willie Barr. (*Applause*) In thinking of his future I am sure we shall all say that we hope his healthy dissatisfaction with inefficiency will long continue.

'With regard to the other two, I am reminded of the young daughter who came home from school one day and said to her father "Daddy, what is vice?" Her father had been waiting for this moment, and he proceeded to give her a lecture which he had prepared with great care on the subject. When he had finished he said "I hope you understand now, dear". His daughter replied that she did and it was interesting. Her father

then inquired why she had asked him, to which the girl replied "I have just been made vice-captain of our hockey team". (*Laughter*) We have just made two Honorary Vice-Presidents. The first is Dr Howard Biers, whom we welcome, and the other is one of our oldest friends, Tom Colclough. Almost everything we do today in the steel industry was advocated by him 40 years ago. We can only hope that he lives to see today's recommendations taking shape 40 years hence. (*Applause*)

'Finally I come to Sir Roger Makins who will reply to this toast. Sir Roger is a lawyer, an Ambassador, an economist, and the manager of a modern scientific activity. It is an enormous combination. In all his years in the diplomatic and other government services he never got into the habit of saying yes when he meant perhaps. Nor did he ever get down to the speed of decision-making which is normal for people in government service. He did not come down to that speed for he is an extremely fast worker, and when he joined the United Kingdom Atomic Energy Authority within the first day he learned where the uranium was! (*Laughter*) As a member of the Government Economic Planning Board he is, I hope, pleased with the steel industry's plan. Therefore, I should like members of The Iron and Steel Institute and industry to rise and to drink with me the health and prosperity of our guests coupled with the name of Sir Roger Makins.' (*Prolonged applause*)

Sir Roger Makins

Sir Roger Makins, G.C.B., G.C.M.G., *Chairman, United Kingdom Atomic Energy Authority, in response, said:* 'When you, Mr President, honoured me with an invitation to respond to this toast, you said that the speeches were to be short and light. I feel that brevity will pose no problem, because one can always remember that remark made by the wife of an after-dinner speaker when he had sat down. He turned to his wife and said "My dear, was that all right?" to which she replied "Well, I thought you missed one or two opportunities". He said "What do you mean?" to which his wife replied "I meant opportunities to sit down". (*Laughter*)

'Lightness is another matter. I am speaking for some very important people here tonight! Ambassadors, High Commissioners, and, Sir Eric, Australia is going to be very much in our minds this summer – if we have one; the President of the Royal Society and, I had hoped, the Chairman of the Coal Board, because I thought it would be rather fun for a representative of a new and upstart fuel to respond for Old King Coal himself! (*Laughter*) But that will have to be for another occasion.

'My fellow guests must pack a punch unequalled in the world. Moreover, it is an increasingly peaceful punch. Gone are the days when cold steel was a symbol of war, and when steelmakers were labelled as merchants of death. Now iron and steel are only thought of as a way to industrial development, of economic growth, and, as Sir Howard Florey said, of civilization itself.

'There are many ways of expressing thanks. There is, for example, the formula used by the young American boy who wanted to enlarge his stamp collection. He wrote a letter to God asking for $100. The United States Post Office, with that political acumen for which it is so justly celebrated, sent the letter to the White House. An amused president directed that $5 should be sent to the boy and that was done. In his letter of thanks to God some time later the boy wrote "Dear God, thank you very much for your gift. I note that you routed your reply through the White House, and as usual those blighters have deducted 95%." (*Laughter*) Tonight the thanks of my fellow guests are being routed through me. I do not propose to make any deduction, but to add an increment of my own, because it is a pleasure as well as a privilege to attend this annual dinner of your celebrated Institute, which not only represents the combined technological skill and knowledge of the British steel industry, but brings together members and representatives of the industry from the Commonwealth, the United States, Europe, and many other countries. I find the task of replying for the overseas guests especially congenial. It seems to me that the common practice of a profession or a discipline is the finest basis for international understanding and good fellowship. An informality prevails which is often difficult to achieve between official representatives, and if competition should introduce a jarring note or a brittle fracture should threaten to appear in the relationship, it can often be prevented by combining again in criticism of governments, or even fire a broadside at that still more congenial target – the bureaucrats from whose ranks I so recently graduated with third-class honours in science! (*Laughter*) I was proud to belong to that much-maligned tribe, and many of the stories told against them frequently redound to their credit. For example, there is the version of that old story of the three gentlemen in a car who asked a yokel where they were, and he told them that they were in a car. Two of the occupants of the car were indignant, but the third who happened to be a civil servant, said he thought it was a most meritorious reply. It was, he pointed out, accurate, it was concise, and it added nothing to the information already available! (*Laughter*) But I was saying that a common professional interest can transcend or muffle intergovernmental arguments, and I am sure that I speak this evening for a fund of international good fellowship and goodwill among the representatives of the steel industry, associations, and institutions represented here. Amid the clatter round the Council tables, amid arguments about federal and confederal groups, about the surrender of sovereignty, about Sixes and Sevens, and so on, the industrialists can make their own contacts and arrangements, and scientists, technologists, and academic and professional men and women can pursue the even tenor of their way, making friends and influencing people in ever widening circles. What better way can there be of furthering this beneficent process than a great occasion such as this, and the meetings which will follow it? In holding these gatherings your Institute helps to lay the ground work and create the atmosphere through which the efforts of governments to achieve a greater unity of policy and purpose among the nations can be crowned with success.

'It is time I fulfilled the promise of brevity, and I shall do so by adopting the procedure of the Scottish minister who ran out of material during the time allotted for extemporary prayer and who said "Lord, I will now tell Thee an anecdote"! This anecdote is about another minister, this time from the southern states of the United States who had lost his bicycle, and strongly suspected a member of his congregation of having stolen it. So he sent for the churchwarden and said "Joe, I shall preach against that man on Sunday and on all the Ten Commandments. I shall show him up." On the following Sunday, the minister got up and preached his sermon, and he was finishing with the Seventh Commandment when suddenly he sat down. The churchwarden went up to him after the service and said "What happened? Why did you sit down?" "Well", replied the minister, "I was just finishing with the Seventh Commandment and was about to move on to the Eighth when I suddenly remembered where I had left my bicycle!" (*Laughter*)

'I thank you on behalf of all your guests for a most delightful evening. I am sure they will all agree with me that they have been well and truly toasted!' (*Prolonged applause*)

The proceedings then terminated.

Co-operation with The Institute of Metals and The Institution of Metallurgists

Notice to Members

AS PREVIOUSLY ANNOUNCED, steps recently taken to improve co-operation between The Iron and Steel Institute, The Institute of Metals, and The Institution of Metallurgists include the setting-up of a Joint Consultative Committee and the adoption, with effect from 1 January 1962, of joint subscriptions to cover membership of the Institution and of one or both Institutes.

As a result it is expected that qualified metallurgists, who are at present members of The Institution of Metallurgists only, will apply for membership of one or other of the two Institutes.

It is known that there are a number of practising metallurgists who are members of The Iron and Steel Institute or of The Institute of Metals but not of The Institution of Metallurgists, although they would qualify for admission to one of the grades of membership of the Institution. Co-operation between the three societies will be assisted, to the benefit of all concerned, if such professionally qualified members of the Institute would apply now for admission to the professional body.

Admission to the Institution's grades of membership is, as is necessary in a qualifying body, strictly governed by formal regulations and standard procedures of selection to which all applications for admission must be submitted. Particulars can be obtained from the Registrar-Secretary of the Institution at 4 Grosvenor Gardens, London SW1. He or senior members of the Institution will be pleased to answer preliminary enquiries and to give such guidance as they can: for example, as to the appropriate grade of membership for which to apply.

The Council hope that members of the Institute who are qualified practising metallurgists and who are not members of the Institution will make this the occasion for applying for joint membership.

A note on the various grades of membership in The Institution of Metallurgists is given below as well as a table showing the additional cost to a member of the Institute. Further information on joint subscription rates was published in the June issue of the *Journal* (p.180).

The Council of The Institution of Metallurgists has decided to remit the application fee of 2 *gns*, normally payable at the time of application, for all those applicants who are members of The Iron and Steel Institute or The Institute of Metals, and who apply to become members of the Institution before 31 March 1962. The usual entrance fees will be payable on election.

It is suggested that members of the Institute who intend to apply for membership of the Institution should not wait until next year but should do so now, stating that if elected they wish their membership to date from 1 January 1962, when the new joint subscription arrangements come into force.

By Order of the Council

Grades in The Institution of Metallurgists

The following information has been supplied by the Institution:

Corporate Members are the Fellows and Associates

Fellow

Minimum age 35. Total in grade at 31 March 1961: 936 (111 of these are overseas).

A Fellow is a person who has satisfied the Council of the Institution that he has an established reputation as a metallurgist. Only the distinctly above-average metallurgist will, by the time he reaches the minimum age, have established the necessary reasonably widely acknowledged and mature reputation as a metallurgist who, either in science or practice, is making a marked original contribution of his own.

Associate

Minimum age 25. Total in grade at 31 March 1961: 2360 (297 of these are overseas).

An Associate is a person who has reached the age of 25 and who has satisfied the Council that he is fully qualified to bear professional responsibility as a metallurgist. Associates are admitted on grounds on the one hand of academic qualification in metallurgy at the level of an honours degree or after direct written or oral examination, coupled on the other hand with periods of satisfactory responsible experience in the science and practice of metallurgy, the minimum experience being variable, according to the standard of academic qualification.

Licentiate

Minimum age 21. Total in grade at 31 March 1961: 1248 (171 of these are overseas).

A Licentiate is a person who has reached the age of 21 and who has satisfied the Council that he has an adequate knowledge of metallurgy, by passing an acceptable *written* examination, and has had not less than two years' direct and sufficiently responsible experience in metallurgy. It is now the normal expectation that admission to Licentiateship is the preliminary step to transfer at a later date to Associateship and so to corporate membership.

Enrolled graduate

Minimum age 20. Total in grade at 31 March 1961: 61.

Minimum qualification a degree or diploma in metallurgy recognized by the Institution as giving exemption from the Institution's Associateship examination; or having passed that examination. No experience is required. Any enrolled Graduate may, at the discretion of the Council, be required to apply for election to membership after an appropriate period in the grade; this period may in no case be more than 5 years.

Enrolled Student

Minimum age 18. Total in grade at 31 March 1961: 512.

Minimum qualification: ONC in Metallurgy or equivalent.

Cost of joint subscription

Grade to which Institute members may be elected to Institution membership, subject to the normal procedures of the Institution for satisfying its regulations and standards of qualification		The new Institution standard subscription (to cover one Institute and the Institution)	Extra gross payment due from an Institute member who is elected into a grade of Institution membership	Approx. net increased annual cost to Institute member who joins Institution, assuming relief of Income Tax at standard rate (7*s* 9*d*) on both his present Institute and new standard Institution subscription
Grade	Age	£ *s* *d*	£ *s* *d*	£ *s* *d*
Fellows	(all over 35)	9 10 0	4 5 0	2 13 0
Associates	Aged 28 or over	6 10 0	1 5 0	0 16 0
	25–27	5 0 0	1 17 0	1 5 0
Licentiates	Aged 28 or over	5 0 0	(*saving of 5s*)	(*slight saving*)
	25–27	4 0 0	0 17 0	0 12 0
	24 or less	2 10 0	0 15 0	0 11 0
Graduates	Aged 28 or over	3 15 0	(£1 10*s saving*)	(10*s* 6*d saving*)
	25–27	3 0 0	(*slight saving*)	(*slight saving*)
	24 or less	2 10 0	0 15 6	0 11 0
Students	Aged 28 or over	3 15 0	(£1 10*s saving*)	(10*s* 6*d saving*)
	25–27	3 0 0	(*slight saving*)	(*slight saving*)
	24 or less	2 0 0	5 0	(*slight increase*)

Note Entrance fees payable on election are: by Fellows 7 *gns*; by Associates 5 *gns*; by Licentiates 3 *gns*.

The integration of production planning, electronic data processing, and process control

W. F. Cartwright and G. W. Thomas

SYNOPSIS

The general case for using electronic computers and some present limitations are noted. The present state of developments in the three broad fields of computer applications, namely production planning, electronic data processing, and process control, are discussed. Both production planning and process control are as yet embryonic in the UK steel industry; the problems of electronic data processing appear to be less intractable. Ultimate integration of these three lines of development within a company is proposed as an ideal, which should enlighten immediate policy. The basis of integration is partly visionary and partly arises from the nature of computers. Information handling is noted as an important feature of the problem of integration. Finally, a solution is discussed to the question of the best form of company organization to promote integrated computer development, and the present organization in the authors' company is described. 1972

INTRODUCTION

THE APPLICATION of computers to the operations of steelworks is developing apace; this is now more obvious abroad than in the UK. Three broad fields of application are apparent: (i) production planning; (ii) electronic data processing; (iii) process control. Many companies are studying and a few are operating embryonic systems of production planning, particularly of rolling mills. The leaders in this field are the Homestead Works in the USA and Sollac, the French company. Similarly, electronic data processing is reaching a level of development where no large company is likely to operate without its assistance. The foremost examples are again to be found in the USA, the US Steel Corporation computer installation at Pittsburgh leading the way. Germany has now strongly entered this field through the mechanization of her steel industry's 'Betriebswirtschaft' organization. There is also evidence of a growing body of computer applications to the control of production processes. Those which have been reported cover the entire range of steelworks processing operations: coal blending, sinter manufacture, blast-furnace burdening, pneumatic steelmaking, the slabbing mill, hot strip mill, and tandem cold reduction mill.

This paper considers briefly the general case in favour of using electronic computers, but its main theme is the immediate development of these three broad fields of application in the light of, and leading to, their eventual integration. It is possible to be specific about each field of application separately, but integration of them lies some years away: integration is therefore discussed as an idea and ultimate goal.

THE CASE FOR COMPUTERS

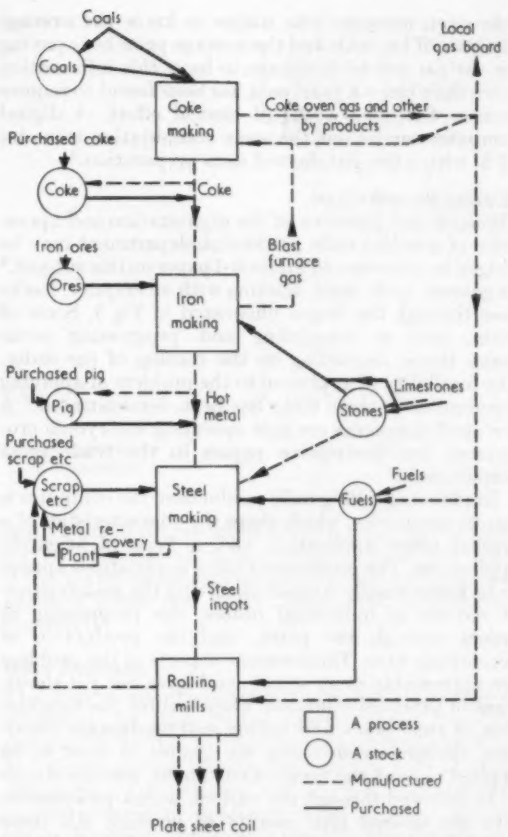
Enthusiasm for the applications of electronic computers is based on less direct reasons than the anticipation of immediate financial savings. It derives from an appreciation of the characteristics of computers. At the same time, certain limitations have to be recognized.

Users of computers have commonly found their outlook undergoing a fundamental change, as experience and understanding grow. Problems which have previously been considered insoluble, either by reason of their logical intricacy, or the masses of clerical work associated with them, are found now to be capable of solution, even as routine procedures. New horizons are opened, giving rise to an increase in intellectual curiosity, which asks further questions and so further extends the scope of the machine. It becomes possible to tie together functions which are now regarded as necessarily separate, introduce controls between functions which are at present considered impracticable, and make possible a reduction in paper work and duplication of effort. In addition, computers can be used to control processes, leading to an increase in the productivity of plant, through one or more of the channels of improved quality, improved yield, closer tolerance, more consistent attainment of tolerance, and sustained output.

On the other hand, computer programs must always be written in a formal language which is rigid, precise, and detailed. There are wide variations between machines in the nature and speed of input and output, especially printed output, and economic limitations on quantity of storage and access time to stored information. The machine time necessary to carry out computing routines, even apparently elementary ones, can be over-long in some cases.

Manuscript received 6 April 1961.

W. F. Cartwright is assistant managing director and general manager of the steel division of the Steel Company of Wales Ltd; G. W. Thomas is manager of the operational research department.



1 *Simplified scheme of works operations as basis of analogue*

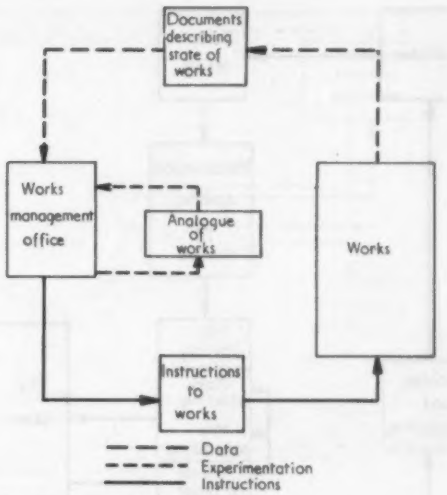
APPLICATIONS OF COMPUTERS

Production planning

Production planning in any industry is, of course, dominated by the state of the market for the products of that industry. The electronic digital computer is already well advanced as a tool of market research[1] which may sometimes be a quasi-scientific application,[2] or one in which the machine is used to record and study the movements of makes, incomes and prices, and stocks. Although such work is frequently carried out by a company's sales department, it should properly be regarded as an integral part of works production planning. In this connexion, a computer-operated system would continuously record and process information concerning the requirements of customers, deliveries to them, their makes and stocks, and what is known of their plans for the future, to enable forecasts to be made of the likely needs of these customers.

General or works management

The problem facing general or works management may then be stated as follows. Given an order book which is likely to be filled in the future to a known proportion, the problem is to conduct operations at an appropriate level. At present, a common solution to the manifold problems of works management is to employ experienced assistants, and perhaps to use the office as a training position for younger men of promise. The defects of this type of solution and the many further problems to which it gives rise are well known.



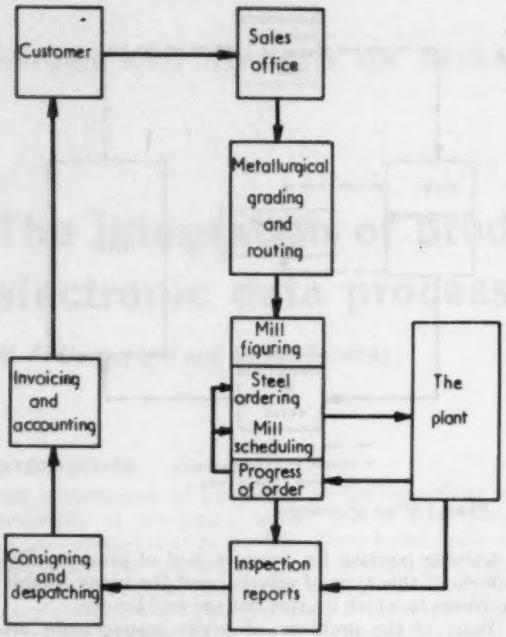
2 *Phase I of use of analogue*

Many of the problems of works management are essentially office problems, which will be discussed shortly. In general, these are less intractable than problems with an appreciable technical content, which typify works management. A possible contribution which the electronic computer might make would be to operate an analogue of the works, on the lines illustrated in outline in Fig.1. The outputs of the major productive units would be specified as functions of their inputs, and allow for an output of a later process being an input of an earlier one (e.g. coke-ovens fired with blast-furnace gas). Stock movements would also be expressed as functions, depending on the makes and inputs of related works processes. Such an analogue has not yet been realized in practice, as many questions remain to be investigated. In spite of its being called an analogue, it might consist of a suite of programs on a digital computer. The information supplied to works management is already in digital form, and a general purpose digital computer would have the flexibility to deal with changing circumstances. On the other hand, an electronic analogue would probably operate at a higher speed, and would be likely to have sufficient accuracy for the required purpose.

If and when such a machine could be designed, it would need to develop through various phases from its likely immediate use, where works management would employ it as an adjunct to its own powers of prediction (Fig.2), to some unknown future time when the machine itself in some way 'advises' management. As both management and the technologists responsible for its development will require to gain experience of such a novel tool, it is thought that an advance to the first phase would be sufficient to consider for the time being. A very advanced concept is, however, quoted in the references to illustrate possible developments in this field of application.[3]

Departmental management

The problem facing departmental management has



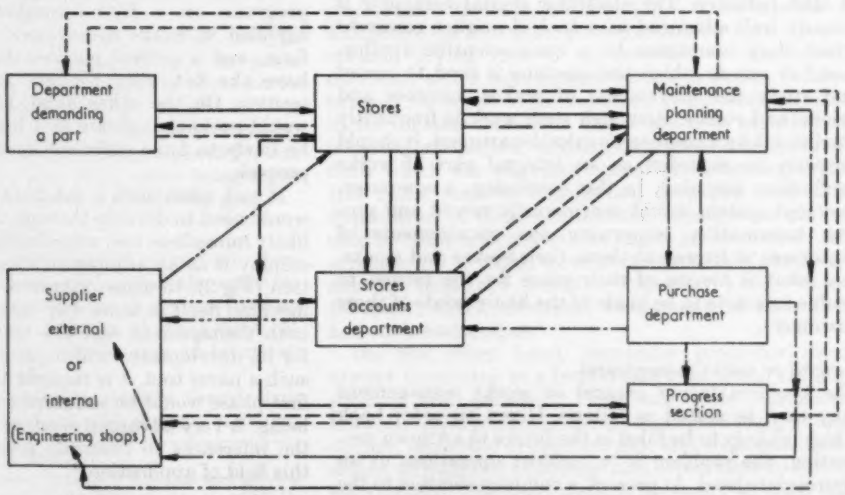
3 *Scheme of meeting order book*

many of the characteristics of the problem of works management, particularly the need to assimilate and act on the voluminous information thrown up by the daily operation of a productive process. The question of automatically recording data will be discussed in a later section of the paper. Meanwhile, the use of a digital computer to record, sort, summarize, and abstract the significant detail would clearly be advantageous, as a substantial step towards the realization of 'management by exception'.[4] In a hard-pressed and inadequately equipped plant office, there is rarely enough clerical capacity to review progress on average, except at quite infrequent intervals. For example, the coke-oven manager who wishes to know the average analyses of his coals and the average price he is paying for carbon will be fortunate to have this information more than twice a year, as it has been found to require four or five man-weeks of clerical effort. A digital computer carries out the same computation in under $1\frac{1}{2}$ h, with a few girl-days of data preparation.[5]

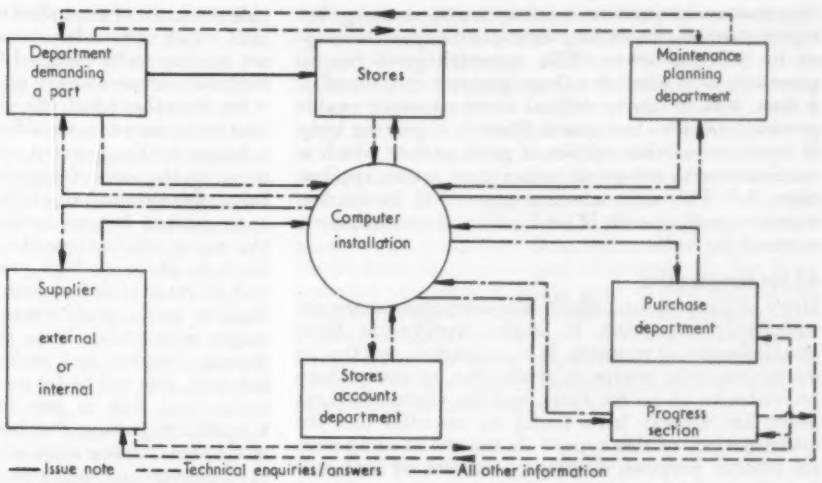
Meeting the order book

The scale and intricacy of the organization and operations of a rolling mills production department may be judged by reference to a detailed paper on this subject.[6] In general, each order, starting with an enquiry, has to pass through the stages illustrated in Fig.3. Some of them, such as 'scheduling' and 'progressing' occur many times, depending on the routing of the order. The feasibility of a solution to the problem of applying a computer to these tasks has been demonstrated.[7] A few steel companies are now operating embryonic procedures, but descriptive papers in the trade press remain rare.[8]

In planning rolling mills production, the computer is put to many uses, which share the characteristics of a typical office application and a type of scientific application. The problems of office applications appear to be fairly readily soluble, involving the maintenance of records of individual orders, the progressing of orders through the plant, and the production of accounting data. The scientific aspects of the problem are appreciably more severe, and have not yet shown signs of practical solutions. They involve the formulation of steel plant and rolling mill production schedules, decisions concerning the grades of steel to be applied to meet the needs of customers, and the routes to be followed through the various works processes to give the desired final quality of product. All these decisions are at present made by experienced clerical staff, who work in close contact with the plant. The systems analyst and programmer are faced with the problem of constructing an analogue of the production planning office, which performs no less efficiently than the existing methods. Measures must be devised to distinguish a better schedule from a worse one, and the



4 *Office procedure as now*



5 *Office procedure computerized*

many rules of thumb which lead a scheduler to produce a given schedule must be revealed. In addition, there is the major technological problem of communication between plant and office, which will be discussed separately.

Office procedures

The work of an integrated iron and steelworks may be identified by the departmental heads normally responsible for it, and listed under some eight headings as follows: selling; buying; personnel records and pay; engineering, maintenance, and new work; manufacturing and processing; operating works services; accounting and costing; controlling quality. The clerical procedures associated with these activities probably all fall into the digital class, as the records are normally in digital form, and the flexibility of the digital computer will probably be needed to handle variations. They share the characteristics of all office work, namely: receiving information; sorting; collating; computing; abstracting and summarizing; filing; transmitting.

A digital computer is peculiarly suited to carry out these tasks, as they involve the transfer of information between sections of a store and computing. Also, these applications illustrate the notion of integration most clearly, as the many office procedures are themselves inextricably intertwined, although placed under different heads for management purposes. To take simply one example, the control of engineering spares involves the plant maintenance department, the purchase department and progress section of that department, the stores accounts section of the accounts department, the stores themselves, and the company's engineering services. These half-dozen departments handle more or less the same information and pass it to and fro in the form of documents, as illustrated in Fig.4. The electronic digital computer does not respect the conventional boundaries, and the systems analyst would try to place all common information in a common store, from which the various users would draw as required. This leads to a different concept, which is illustrated in Fig.5. In addition to the economics of partial integration, the computer system would lead to greater efficiency in answering enquiries, more economic control of stock levels and stock locations, better use of staff and possibly a reduction in numbers and more accurate record keeping. The realization of benefits and savings like these is now widely accepted as the consequence of well designed computer systems, applied to office procedures.[9,10]

Process control

The term 'process control' is being used to avoid the more controversial term 'automation'. A process control system may consist of a closed loop feed-back, which does not require a computer of any type, or it may consist of either an analogue computer or a digital computer, which is charged with the first-priority duty of controlling a piece of plant. The choice of the computer to use, and indeed the choice of a computer as against a closed loop feed-back, will depend on the speed and accuracy required, and the cost of the system. An electronic analogue computer will often be the most appropriate, as the majority of signals from the plant will already be in analogue form, and the speed of the analogue computer will be required. Nevertheless, there are likely to be applications in a steelworks where a digital computer would be more suitable, if much of the source information is already in digital form. The card-programmed rolling mill provides an obvious, if slightly old-fashioned, example.

The application of process control computers is approached from two interdependent viewpoints, namely the engineering and the operational. The engineer is concerned with the exploitation of technological developments, which enable him to apply process control to a piece of plant. For example, the problems of instrumentation and position control appear under a particularly harsh light when process control is considered, as higher standards of accuracy and dependability are necessary than are at present commonly attained. On the other hand, operational studies show the scope for process control and the need for further engineering developments: studies of a continuous hot strip mill have recently revealed that the finishing mill train is out of use for some 25% of the time, of which some 10% or 15% may be ascribed to a certain measure of lack of control of mill operations.[11] Other studies, still in progress, are confirming

that steelworks practice is not a consistent thing but highly variable, depending on the techniques developed by different crews. This approach gives rise to questions as to whether a 'best' practice exists, and, if it does, how it can be defined in terms which enable process control to be applied. There is a growing body of literature on this subject, a great part of which is concerned with potential rather than actual applications.[12, 13] The main advance appears to be concentrated on rolling mills of all kinds, and on pneumatic steelmaking.[14, 15]

Ad hoc investigations

Many of the problems which face management are not sufficiently repetitive to make worthwhile their establishment as routines. It is a common practice to set up scientific groups in steelworks, to study these problems on an *ad hoc* basis, and the electronic computer has already been found an essential tool for investigations of this type.[16] As the use of computers for routine purposes develops, a wealth of data will become available to these study teams; at the moment it poses a mighty problem of collection and analysis. This topic lies outside the brief of this paper, but a typical example is quoted among the references.[17]

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It is used in the title of this paper in this wider sense, and is part of a vision, whereby all the various computer functions within a company are to be ideally conceived as if they were operated on one enormous installation with a common store. Without this vision, the danger of creating a formless aggregation of isolated and piecemeal computer routines is considerably increased, resulting in a much smaller return from the outlay than one would believe to be possible.

There are technical, economic, and social objections often raised to the idea of integration. It is unlikely that all the machines applied throughout a complete works will have the same characteristics, and this will prevent information being readily transferable between one machine and another. This possibly lays the economics of very large installations open to doubt, not only in the broad terms of possible losses of efficiency due to large-scale operation, but also simply because machines may be bought which are more expensive than would be strictly necessary if the cheapest manufacturer were approached in each isolated case. The social objections are likely to affect both managers and operatives, when jobs which were once regarded as involving peculiarly human skills are carried out at least as well by machines. Already the independence of the individual and the reliance on his skill, which have so far characterized the steel industry, are tending to be replaced by defined and disciplined routines, and an absence of individual flexibility.

On the other hand, the view which favours integration is inspired to a considerable extent by a vision of a future works, operated by a single-minded management, on the basis of processed data, implying a knowledge of events and an ability to make forecasts, which is at present beyond realization. The drive towards this vision will be supported by economic factors, particularly the very high prices of computing systems and shortage of skilled computer staff, which is hardly likely to lead a single company to have more than one major installation. It is therefore thought that although complete and perfect integration may not be attained, this will be for technical reasons rather than social, and that in any case the tendency will be towards integration. Further considerations in support of the idea of integration arise from the essential unity of computers and their role in operating works control systems.

The unity of computers

There are essentially two different classes of computers, digital and analogue. In each class, it is possible to combine the basic logical, arithmetical, and organizational operations in an exceedingly large number of different ways, thereby enabling exceptionally complex problems to be solved. The idea of 'the unity of computers' should be understood to refer not only to the similar hardware which is used in the construction of these machines, but rather to the identity of the simple and fundamental operations of which each class is capable.[19, 20]

It follows that digital computers, for example, cannot satisfactorily be distinguished by reference to their various fields of application: accounting, production planning, process control, scientific computation, and so on. Actual developments in the computer market tend to support this thesis. A particular machine, sold primarily for process control, samples five analogue signals per second, but has as many as 150 ms available in every 200 ms for work other than process control. On some applications, there may be several minutes available at a time, which can be profitably applied to operating mechanized procedures of a lower priority than the process control procedure. Each departmental manager's process control machine (or machines) could possibly carry out his clerical work more or less simultaneously with the process control duties. A further example is found where a manufacturer offers machines of differing capacities having a 'family likeness', which enables programs, storage media, and possibly other facilities, to be interchanged between different machines in different locations. Both of these developments greatly increase the scope for unification of communications, and hence for the integration of computer operations.

Computers and control systems

In general terms, a control system may be defined by reference to five components, as follows:

(i) a means of registering and (if necessary) storing information
(ii) a means of processing this information, whether newly received or from store

(iii) a means of taking a decision on the basis of this processed information
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(v) a means of assessing the correctness of this decision and 'cycling' around the components to take further corrective action, as necessary.

Such a control system may be completely automatic, partly automatic, or completely non-automatic. A completely automatic control system of an advanced kind, where the information processing and decision-making procedures are complex, involving several variables and complicated rules, would deserve the name of automation, and examples might be found from advanced process control applications of electronic computers. Non-automatic control systems are frequently seen in steelworks, where an operator receives information from instruments, processes this information entirely in his own head, and operates the controls of the plant to achieve some end. The initial application of electronic computers will probably be to increase the number of semi-automatic control systems which are in operation. These might be found at various levels, up to senior management, but a single principle is discernible, on the lines indicated in the definition of a control system above. It is likely to turn out that, in many applications, the first two components could be made completely automatic, the third component partly automatic, the fourth and fifth components frequently non-automatic, being the prerogative of an operator or a manager.

Thus, it is possible to view a works or a company as an exceedingly complex and large series of interacting control systems and sub-systems. At the moment, many of these exist in a partly developed form, mostly lacking the essential fifth component, which effectively introduces the element of control. In effect, this fifth component is a means of ensuring that an instruction has been obeyed or is itself modified, to achieve the desired end.

Supply of information

The dependence of a control system on a properly regulated flow of information, both to receive data from the plant and to issue instructions to it, will be apparent. Managers at all levels need to know the 'state' of their commands: that is, the stocks, materials movements, makes, stoppages, manning, and other factors which contribute to the managerial picture. The planning and control of rolling mills production requires the issue of instructions to the mills, and the receipt of reports confirming that these instructions have or have not been met. In the office, source documents must be converted into a form appropriate to the input media of the computer installation, enquiries must be initiated and the replies interpreted, and many intermediate inputs and outputs of information must be handled. On process control applications, the five senses, and perhaps the intangible 'sixth sense', of an operative must be replaced by devices which will register and handle information concerning the changing states of a process. The problem of measuring much of the information now supplied by sight, touch, and even smell or taste continues to be especially intractable. For the purposes of *ad hoc* investigations, facilities need to be provided which will enable data to be collected temporarily.

Disparate control systems are already operating in every company. The problem of relations between these different systems, which is the problem of co-ordinating and regulating the diverse parts of a complex enterprise, cannot satisfactorily be solved until a large measure of integration has effectively been achieved. Information handling is both the means of integration and a main obstacle, in the present state of technology. For example, if a company's rolling mills are computer controlled, and if its mills production is planned by computer, then integration of the two would seem an obvious goal of endeavour. Too little practical attention is being paid to overcoming the obstacles in the UK steel industry at the moment. The paucity of examples in the UK[21] contrasts with the German steel industry, where economic justification appears to have lagged behind the drive to achieve operational information systems.[22]

Organizing for an integrated computer system

A common organizational theme is now emerging from the many companies and other bodies facing the introduction of computer systems.[23] A theoretically ideal solution may be proposed which follows naturally from the thesis of the unity and integration of computer systems. Since a computer system does not respect conventional boundaries between departments, they should certainly not be allowed to influence its introduction and development. The ideal solution would be to set up a new department, charged with the responsibility of devising and introducing computer routines throughout the company. In view of the common experience of a loss or change of direction between the development phase of a project and its practical application, in the case of computers the development team and the routine operational team should be placed under the same head, forming two sections of the newly established computer department. The role of the department would then be to provide a service to the member departments of the company as a whole, to achieve the aims of the members acting as clients, and to be responsible within itself for achieving an integrated system of operation.

In considering such an organization in a British industrial company, the special positions of the company secretary and the chief accountant must be respected. Under company law, these officials have responsibilities, particularly for financial matters, which cannot be delegated to a service department of any kind. There is then a real danger of a dual organization arising, in which the essential accountancy routines are carried out in one installation under the chief accountant, while the other routines (production planning, etc.) are carried out in a second installation.

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department. To this end, the organization and methods department is being increased in strength and diversified by taking on systems analysts and programmers in addition to the existing staff with operating experience of punched cards and electronic computer systems. Responsibility for the development of process control by computer lies with the automation department, a branch of the electrical engineering department. Both of these departments are able to use the services of the operational research department, which has its own digital computer solely for research and development studies. Co-ordination of overall computer developments, leading to ultimate integration, is the joint responsibility of these three participating departments, in the sense that all new proposals are discussed in committee to ensure compatibility between schemes. Any one of the three departments is free to propose fields and methods of investigation of computer applications to this committee.

Management is confident that this form of organization will make best use of the company's resources, and lead to an integrated computer system for the company.

CONCLUSION

Development and integration of computer systems is, of course, a task which will never be completed. The new orders of speed of computer operation show every sign of being able to make concepts practicable that are now academic. Most promising (for this paper) is the study of processes of thought and behaviour, which appears likely to lead to utterly new notions and techniques of managerial control. To ensure their wide practical application, an advanced degree of integration of information handling will be essential. It may even prove possible to conduct operations on a wider basis than the individual company, say regionally, or industry by industry.

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Notes for Authors

A 16-page booklet entitled 'Notes for Authors' has recently been published by the Institute. It is divided into two sections, covering 'Publications' and 'Presentation at Meetings' respectively. It is designed to provide prospective authors of papers for publication in the *Journal* or for presentation at one of the Institute's Meetings with answers to all the questions they are likely to ask.

Thus the first section deals with the way in which manuscripts should be prepared, the 'house style' for abbreviations, spelling, punctuation, etc., the best way of preparing illustrations for the printer, and similar problems. The most valuable part of the second section is perhaps that giving recommendations on the preparation of slides for projection at meetings. Guidance is also given on the best way of preparing the verbal presentation of a paper for delivery at a meeting.

Copies of the booklet are available free to Members of the Institute, and may be obtained on application to the Assistant Secretary. Librarians and Information Officers of companies, research organizations, institutions, and teaching bodies, are also invited to apply for free copies.

A simplified hot-extraction apparatus for the determination of hydrogen in steel

C. E. A. Shanahan and F. Cooke

SYNOPSIS

The performance of a simplified hot-extraction apparatus for the determination of hydrogen in steel has been compared with the well-known vacuum heating procedure. Steel samples were loaded with hydrogen under controlled conditions and then analysed by both vacuum techniques. The errors of the simplified procedure are assessed and compared with possible calculated errors. It is concluded that the simplified unit may be used to determine the total gas evolved from plain carbon steel with a maximum error of 0·3 ml/100 g. To convert the total gas volume to hydrogen volume, the gas composition must be assumed. Experience has shown that, under the recommended extraction conditions, 90–95% of the total gas is hydrogen.

1963

INTRODUCTION

THE HYDROGEN CONTENT of steel may be accurately determined by heating the sample *in vacuo* and measuring the quantity of hydrogen evolved. It is necessary in such a procedure to ensure the complete removal of the hydrogen from the sample and this is accomplished by maintaining a negligible hydrogen pressure within the hot sample chamber by the use of vacuum pumps and generally collecting the gases in a separate vessel. The hydrogen content of the gas evolved will, of course, depend on the type of sample and extraction temperature employed and some method of gas analysis is usually incorporated within the procedure.

The apparatus required for the above is bulky and fragile, involving the use of expensive vacuum pumps etc., and is not generally suitable for steelworks laboratories. To meet this situation the authors developed a carrier-gas procedure[1] in which the hydrogen from the hot sample was transported by nitrogen from the sample chamber and oxidized to water which in turn was determined by absorption in methanol and titration by Karl Fischer reagent. This technique is specific for hydrogen and it has already been used successfully in steelworks laboratories.

Experience has shown that when the vacuum heating procedure is applied to plain carbon steel samples, using an extraction temperature of 650°C, the total gas evolved contains 90–95%H and usually gas analysis is unnecessary. Moreover, calculations show that if the correct combinations are chosen for sample weight, hydrogen content of sample, and volume of extraction vessel, the total hydrogen can be liberated and maintained within the extraction vessel without incurring an appreciable solubility error due to the hydrogen partial pressure. If, further, the extraction vessel can be evacuated by mercury displacement and the same technique used to compress the evolved gases for pressure and volume measurement, the foundation exists for a simplified vacuum extraction procedure for hydrogen determination. Such a technique would not, of course, yield results of the highest accuracy since gas composition would be assumed. However the presence of hydrogen as water vapour would not cause error providing the final gas compression was insufficient to cause condensation.

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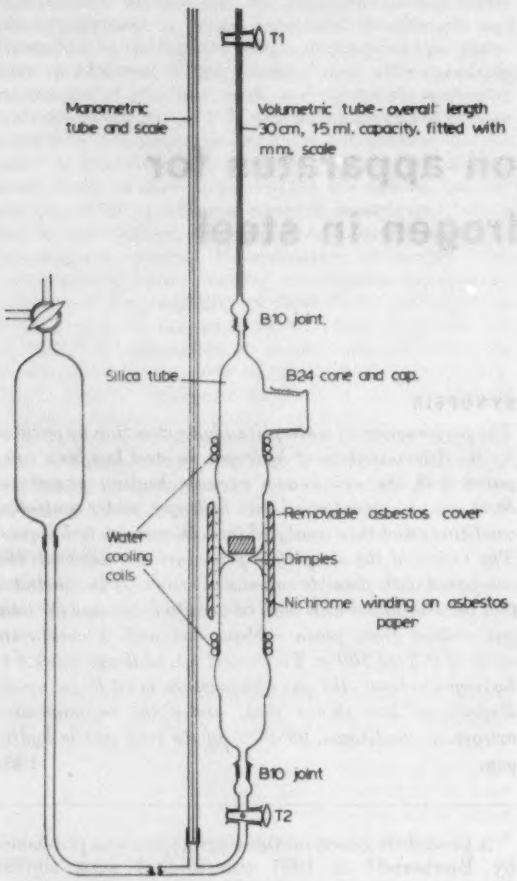
A procedure based on these principles was published by Bjerkerud[2] in 1957 coincidental with similar developments in the authors' laboratory. The extreme simplicity and low cost of the apparatus together with its compactness make it eminently suitable for works laboratory use where the highest accuracy is not required. A comparison has therefore been undertaken of the performance of this procedure and that of the well-known vacuum heating method.[3]

EXPERIMENTAL

Preparation of steel samples

In order to compare the performances of the normal vacuum heating procedure and the simplified method, it was essential to obtain pairs of samples having identical hydrogen contents. Previous attempts[1] at obtaining such samples by removing specimens from adjacent positions in a steel slab were not wholly successful owing to the high diffusivity and marked segregation of hydrogen in steel. It was decided therefore to work with samples loaded with hydrogen in the laboratory. In order to test this method, low-carbon steel cylinders ½in dia. by ⅝in long (for composition see Table IV) were degassed under vacuum at 650°C, and then soaked in hydrogen at 1 atm pressure at temperatures of 1200°, 1000°, and 600°C in a silica tube furnace. After treatment, the samples were quenched in water and stored in liquid oxygen. The reproducibility of the hydrogen contents obtained by this procedure is shown in Table I, which lists the hydrogen



1 *Simplified vacuum heating equipment*

determinations (made by the normal vacuum heating method) on samples loaded at about 1000°C for varying times. The data also indicate that negligible hydrogen is lost by storing in liquid oxygen. These results together with the values obtained at 1200° and 600°C confirmed that about 7 h was required for the samples to reach their equilibrium content of hydrogen, which could be calculated approximately by[4]

$$\log_{10}\frac{S}{p^{\frac{1}{2}}} = -\frac{A}{T} + B \quad \ldots\ldots(1)$$

where S=hydrogen solubility (ml NTP per 100 g metal), p=hydrogen pressure (mm Hg), T=temperature (°K), A=1454, B=0·296 for α-iron in temperature range 300–910°C, and A=1433, B=0·439 for γ-iron in temperature range 910–1400°C.

Description of simple vacuum extraction apparatus

The equipment consists essentially of a 2-cm bore transparent silica tube, 33 cm in length, fitted with B10 cones at each end and with a B24 cone and cap immediately below the top shoulder (*see* Fig.1). A nichrome wire winding on asbestos paper is used to heat the sample which is supported by four dimples while two bulges in the tube, one above, and one below the furnace section, support water-cooling coils. A 3-mm bore volumetric tube of 1·5 ml capacity terminating in a vacuum quality tap T1 is joined to the upper cone of the silica tube by a B10 socket, and a manometric tube, of the same bore as the volumetric tube, is joined into the flexible tubing connecting the mercury reservoir to the vacuum quality tap T2 at the lower end of the apparatus. In operation the nichrome winding is thermally insulated by a detachable asbestos shield and energized by a variable autotransformer.

TABLE I Hydrogen contents of $\frac{1}{4}$in dia.×$\frac{1}{2}$in long steel cylinders soaked for varying times at 1000°C, and 1 atm pressure of hydrogen (normal vacuum heating equipment). Steel: low-carbon steel no.R213

Soaking temp., °C	Soaking time, h	Hydrogen content, ml NTP/100 g	Remarks
1000	2·5	4·4	
1000	5	5·1	
1000	6	5·6	
1000	6	5·6	
1000	6	5·5	
1000	6	5·6	
1000	7	5·5	
1000	7	5·6	
1000	7	5·6	
1000	7	5·5	
1000	7	5·6	
1000	7	5·4	
1000	7	5·6	
1000	7	5·6	
1000	7	5·7	
1000	7	5·7	
1000	7	5·5	Stored 2·5 days in liquid oxygen
1000	7	5·5	Stored 2·5 days in liquid oxygen
1000–1030	12	6·0	

Method of operating simple vacuum extraction apparatus

The procedure for determining the total gas evolved from a steel sample is as follows. Adjust the height of the mercury reservoir so that the mercury level within the heating chamber is just below the B24 cone. Close T2, open T1, and remove the B24 cap. Introduce the clean degreased cylindrical sample ($\frac{1}{4}$in dia.×$\frac{1}{2}$in long) to the side arm, transfer to the mercury surface with a magnet and seal the B24 cap in position with wax. When the latter has cooled to room temperature return the sample to the side arm with a magnet, open T2 and slowly raise the mercury level until it passes the bore of T1. Close T1, drop the mercury level to a position just above T2 and then allow the level to rise slowly until it is close to T1. Cautiously open T1 and dispel any gas. Close T1 and repeat the purging treatment before finally closing T1.

Adjust the mercury level to a position just below the B24 cone and move the sample on to the mercury surface. Transfer the sample to the dimples by cautiously lowering the mercury surface and close T2 when the level is just above the bottom B10 cone. Switch on the heater pre-set to provide a temperature of 650°C at the centre of the furnace zone. When gas evolution is complete, switch off the heater and remove the detachable asbestos shield. After 7–10 min, open T2 and cautiously raise the mercury level to compress the gas into the volumetric tube; measure its volume and pressure. The highest convenient volume should be used in order to avoid errors due to water vapour condensation. Adjust the mercury level to just below the B24 cone, close T2, open T1, remove the B24 cap, and withdraw the sample for weighing.

TABLE II Rate of gas evolution from ¼in dia.×⅝in steel cylinders. Simplified vacuum heating equipment (low-carbon steel no.R213)

Heating time, min	Sample	Sample wt, g	Total gas evolved, ml NTP	Total gas evolved, ml NTP less blank	Total gas evolved, ml NTP/100 g
5	¼in dia.×⅝in cylinders loaded with H_2 at 1000°C for 7 h. Abraded and degreased before determination	14·950	0·64	0·64	4·3
10		14·947	0·67	0·66	4·4
20		15·276	0·80	0·78	5·1
30		15·036	0·86	0·84	5·6
60		14·781	0·89	0·86	5·8
		15·203	0·92	0·89	5·8 (Mean 5·7)
		15·072	0·87	0·84	5·6
		15·023	0·89	0·86	5·7
		15·165	0·89	0·86	5·7
5	¼in dia.×⅝in degassed cylinders Abraded and degreased before determination	c.15	0·0, 0·0	0·0	
10			0·0, 0·02	0·0	
20			0·05 0·06	0·03	
30			0·05	0·03	
40			0·06	0·04	
60			0·08, 0·10	0·06	
			0·09, 0·08		
10	No sample		0·01		
20			0·02		
40			0·02		
60			0·03		

The apparatus is now ready for the introduction of the next sample. It is important, as will be explained later, that the mercury level does not drop below the B24 cone when the equipment is open to the atmosphere.

Measurement of evolution and blank rates

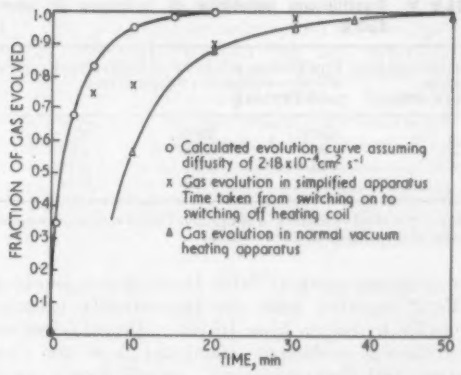
A preliminary series of experiments was conducted to determine the time required for extracting the total gas from steel samples, and the blank rate. The rates of evolution of gas from samples previously loaded with hydrogen (1 atm) at 1000°C were measured by heating the specimens for times varying from 5 to 60 min and measuring the amounts of gas evolved. In each case the recorded time interval was that between switching on and switching off the heater.

Information on blank rates was obtained by conducting two similar series of experiments; in one set the equipment alone was used while in the other, the apparatus was loaded with a degassed sample. All the data are given in Table II.

TABLE III Comparative gas analyses carried out on ¼in dia.×⅝in steel cylinders using the normal and simplified vacuum heating equipments

Sample no.	Sample treatment at 1 atm pressure of hydrogen: Time, h	Temp., °C	Total gas, ml NTP/100 g: Normal equipment	Simplified equipment	Difference (with respect to normal equipment)
18	7	1000	5·2	5·1	−0·1
	7	1000	5·1	5·0	−0·1
	12	approx. 1000*	5·4	5·4	0
	12	approx. 1000	4·7	4·9	+0·2
	24	approx. 1000	5·8	5·8	0
	12	approx. 1200	7·0	6·7	−0·3
	12	approx. 1200	6·7	6·9	+0·2
Low-carbon steel R189	4	600	2·3	2·0	−0·3
	4	600	2·4	2·5	+0·1
	7	600	2·5	2·4	−0·1
	7	600	2·6	2·4	−0·2
	12	approx. 600	2·4	2·3	−0·1

* The temperature of the furnace used for loading the samples with hydrogen was manually controlled. Because of this limitation an approximate temperature only is given for soaking times greater than 7 h.


FRACTION OF GAS EVOLVED
TIME, min
o Calculated evolution curve assuming diffusity of 2·18×10⁻⁴cm² s⁻¹
x Gas evolution in simplified apparatus Time taken from switching on to switching off heating coil
Δ Gas evolution in normal vacuum heating apparatus

2 *Evolution of hydrogen from ¼in dia×⅝in cylinder at 650°C*

Determination of the total gas evolved from steel samples soaked in hydrogen at various temperatures

Pairs of cylindrical steel samples (analysis given in Table IV) were loaded with hydrogen at 600, 1000, and 1200°C for various time periods as already described. After this treatment, the total gas evolved from one sample in each pair was determined with the simple vacuum extraction equipment using a heating time of 45 min. The total gas from the second sample of each pair was determined by the normal vacuum heating procedure,[3] extraction being continued until the gas evolution reached the blank rate. The results are presented in Table III.

RESULTS AND DISCUSSION

There are five main sources of error associated with the total gas content of a sample estimated by the simple vacuum extraction apparatus.

(i) Incomplete gas evolution due to (*a*) an insufficient time of heating, (*b*) hydrogen remaining within the sample owing to the partial pressure of hydrogen within the equipment.
(ii) loss of gas from the sample by diffusion at room temperature during the loading of the sample and purging of the equipment.
(iii) condensation of water vapour during compression of the gas in the volumetric tube.
(iv) variation in blank rate.
(v) volume pressure and temperature errors during the gas measurement.

Each item will be discussed individually.

Incomplete gas evolution

(*a*) The data obtained from the measurements of the total gas evolution rates from hydrogen-loaded

TABLE IV Steel analyses

Sample no.	%C	%S	%Mn	%Si	%P	%Al (total)
18 (vacuum cast)	0·04	0·016	0·06	0·10	0·011	
R 189 (low-carbon rimming steel)	0·06	0·036	0·33	0·005	0·045	0·01
R 199 (low-carbon rimming steel)	0·06	0·050	0·35	0·005	0·040	0·01
R 213 (low-carbon stabilized steel)	0·04	0·025	0·045	0·005	0·033	0·036

TABLE V Equilibrium solubility of hydrogen in steel at 650°C

Hydrogen content of sample, ml NTP/100 g	Equilibrium solubility of hydrogen at various effective equipment temperatures, ml NTP/100 g		
	650°C	335°C	20°C
1	0·09	0·08	0·05
5	0·21	0·17	0·12
7	0·25	0·20	0·14

$\frac{1}{4}$in dia. × $\frac{3}{8}$in steel cylinders in simplified vacuum heating apparatus
Volume of apparatus approx. 125 ml

steel cylinders given in Table II are shown graphically in Fig.2 together with the theoretically calculated curves for hydrogen from $\frac{1}{4}$in dia. × $\frac{3}{8}$in cylinders using the diffusion coefficient calculated from the Sykes, Burton, and Gegg equation.[5] In addition a typical evolution curve obtained using the normal vacuum heating equipment[3] is included on the same graph.

Comparisons between the theoretical and experimentally determined curves must of necessity be approximate since the time values for the latter include the period of heating the samples to 650°C. Allowing for this limitation the type of evolution curve obtained when using the simplified equipment is similar to that anticipated theoretically, and with both equipments evolution is substantially complete after 45 min.

It is interesting to note that the bore of the silica tube used in the normal vacuum heating equipment is about 3·5 cm while that of the simplified equipment is 2 cm, and that this difference is probably reflected in the increased rate of gas evolution over the 0–20 min time period found with the simplified equipment in which the sample probably has a faster rate of heating.

(*b*) The residual amount of hydrogen in solution at 650°C may be calculated from equation (1) at a gas pressure determined by the hydrogen evolved from the sample. Since part of the apparatus is at room temperature and part at 650°C the actual hydrogen pressure will be somewhere between the calculated pressures at these limiting temperatures. The anticipated solubilities given in Table V have been calculated at the hydrogen pressures appertaining at 20°, 335°, and 650°C, using a steel temperature of 650°C and hydrogen contents between 1 and 7 ml H_2 (NTP) per 100 g (the range normally found in production). From Table V it is reasonable to suppose that residual dissolved hydrogen will not exceed about 0·2 ml/100 g at the higher gas contents.

Loss of hydrogen at room temperature

The time taken to load a sample into the apparatus and purge the equipment is about 5 min. During this time period it may be calculated that about 5% of the total gas is evolved at 20°C from a $\frac{1}{4}$in dia. × $\frac{3}{8}$in cylinder ($D = 3{\cdot}2 \times 10^{-7}$ cm^2 s^{-1}).

Water vapour content of evolved gas

When the total gas evolved from a steel specimen is compressed into the volumetric tube for final pressure and volume measurement, the partial pressure of any water vapour is increased and if this exceeds the saturation value, errors due to condensation may occur. It is advisable therefore to use the highest convenient volume for the final gas measurement.

In order to investigate the possibility of condensation errors, the water vapour content of the total gas evolved from steel specimens was determined. Steel specimens were degassed, loaded with hydrogen for 7 h at 1000°C, and quenched. After removing the surface oxide film by abrasion, and degreasing, the total gas evolved from each was measured by using the normal vacuum heating equipment and maintaining the ferromanganese furnace at room temperature. The total gas volume therefore included any water vapour from the sample and this was determined by measuring the change in pressure of the gas at constant volume after treatment with P_2O_5. Table VI shows the quantities of water vapour obtained and includes the calculated water vapour pressures in the measured volume and the saturated vapour pressures of water at the measurement temperatures. It is evident that the water vapour contents are free from errors arising from condensation.

It is interesting to compare the amount of water vapour (0·04 ml NTP) found in the total gas evolved from the steel specimens with the hydrogen pick-up that occurs during abrasion in the atmosphere. Previous work[6] has shown that the abrasion of a steel surface causes an increase in hydrogen content of about 0·005 ml/cm^2 of abraded surface. Each cylindrical sample in the present experiments had an abraded area of 8·9 cm^2 (i.e. the total surface of the sample) corresponding to a hydrogen increase of 0·045 ml of hydrogen or water vapour. The present work suggests, but does not prove, that the hydrogen resulting from abrasion is subsequently released as water vapour.

Equipment blank

During the initial experiments immediately after construction of the equipment the blank tended to be rather high and variable, i.e. about 0·07–0·10 ml and in addition tended to increase with time. It was eventually discovered that most of the blank arose from exposing the internal walls of the equipment to the atmosphere and to the fact that it required cleaning after 8–10 determinations.

The procedure finally adopted and used throughout

TABLE VI Water vapour content of gas extracted from $\frac{1}{4}$in dia. × $\frac{3}{8}$in steel cylinders at 650°C (using normal vacuum heating equipment)

Sample no.	Sample treatment	Total gas extracted, ml NTP	Residual gas after cycling over P_2O_5, ml NTP	Water vapour content, ml NTP	Equivalent value of p_{H_2O} in measurement volume, mm Hg	Saturated vapour pressure of water at temp. of gas measurement
R199	Cut from slab. Degassed and soaked in hydrogen for 7 h at 1000°C. Abraded and degreased	0·88	0·84	0·04	3·2	19·8
R199		0·87	0·83	0·04	3·2	15·5
R213		0·91	0·87	0·04	3·2	16·5
R213		0·77	0·73	0·04	3·2	16·5
Blank		0·05	0·05	...	...	...

TABLE VII Hydrogen contents on sample pairs analysed by the normal vacuum heating method

Sample	Soaking temp., °C	Soaking time, h	Hydrogen content, ml NTP/100 g
18	1000	7	5·2
			5·3
R189	1000	7	4·5
			4·6
18	600	7	1·3
			1·4

the present work ensured that the mercury level was positioned just below the B24 cone when the equipment was open to the atmosphere. If, in addition, the equipment was cleaned regularly with 50% nitric acid, the average blank was 0·03 ml with a range of 0·02–0·04 ml.

Gas volume measurement

The volumetric tube used was calibrated both by the measurement of the diameter of a mercury thread of known volume and by the gravimetric method using mercury as the contained fluid. Both methods showed that after the distorted zone extending 1 cm from the tap junction, the tube was of uniform bore along the full extent of the scale (21 cm) while the absolute volumes measured by the two methods agreed to within 0·01 ml. A value of $\pm$0·01 ml has been taken therefore as the possible volumetric error.

Calculation of the volume of evolved gas at NTP will also include the errors involved in the measurement of temperature and pressure which have been assessed not to exceed $\pm$1°C and $\pm$1 mm mercury respectively. The temperature variation refers to the actual temperature of the measured gas and not to the reading of the thermometer located near the volumetric tube.

Comparative errors

When comparing the results obtained from the simplified equipment and the normal vacuum heating procedure it is necessary to take into consideration, not only the above sources of variability but, in addition, variation arising from errors in sample weights, the normal vacuum heating method, and sample heterogeneity.

The data presented in Table I show that constant hydrogen contents can be obtained by loading times of about 7 h but subsequent work has shown that although this time period was adequate, and the total gas contained about 100%H, the equilibrium hydrogen contents could vary between 4·5 and 5·8 ml/100 g. However, when two specimens were hydrogen loaded together, their hydrogen contents always differed by less than 0·1 ml/100 g; several results on sample pairs analysed by the normal method are given in Table VII. Therefore in order to compare the two analytical techniques, pairs of samples were hydrogen loaded and one sample from each pair analysed by the simplified equipment and the other by the normal vacuum heating technique.

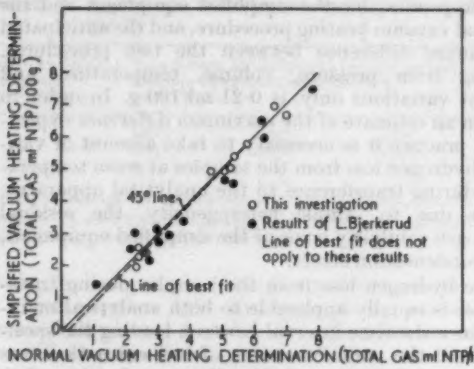
It is possible from estimates of the maximum errors involved in pressure, volume, temperature, and weight measurements to calculate the resultant maximum error in a determined hydrogen content due to these four variables. This calculation has been made (*see* Appendix) for the simplified equipment and the normal vacuum heating procedure, and the anticipated maximum difference between the two procedures, arising from pressure, volume, temperature, and weight variations only, is 0·21 ml/100 g. In order to obtain an estimate of the maximum difference expected in practice it is necessary to take account of variable hydrogen loss from the samples at room temperature during transference to the analytical apparatus, errors due to sample heterogeneity, the residual hydrogen solubility error of the simplified equipment, and condensation errors.

The hydrogen loss from the samples during transference is equally applicable to both analytical methods since the time interval between loading the specimen and the commencement of hot extraction was equal in each equipment. No allowance for this effect is therefore necessary when considering the differences between the results. However, a random error assessed at 0·1 ml/100 g due to sample heterogeneity must be added so that the maximum random error between the two analytical methods is 0·31 ml/100 g. Any biased error due to residual solubility would tend to increase the anticipated difference between the comparative results. The data given in Table III are compatible with the anticipated errors; the maximum difference found experimentally is 0·3 ml/100 g but in most cases the difference is equal to, or less than, 0·2 ml/100 g.

Attention must now be given to two sources of biased error that would cause the simplified equipment to yield low results, namely an error from residual hydrogen solubility in the steel specimen, and an error arising from water vapour condensation. Since the results for the simplified equipment are on average 0·058 ml/100 g lower than those for the normal vacuum heating method, the influence of the biased errors is obviously less than anticipated.

The calculated residual hydrogen solubility error (Table V) was based on a steel sample temperature of 650°C and the much lower value suggested experimentally (less than 0·15 ml/100 g at hydrogen contents up to 7 ml/100 g) possibly arises from liberation of hydrogen from the steel during cooling. Calculation shows that at 400–450°C a sample initially containing 7 ml/100 g of hydrogen might only retain 0·058 ml/100 g of gas at a pressure of 20 to 9 mm respectively within the equipment. The diffusivity of hydrogen in this temperature region is more than 50% of the value at 650°C so that significant hydrogen losses could occur during the 10 min cooling time used with the simplified equipment.

It has been shown previously that the volume of water vapour liberated by the steel samples is 0·04 ml (Table VI). At 25°C, the amounts of water vapour required to give a pressure of 23·8 mm Hg (the saturated vapour pressure of water) in the volumes 0·5, 1·0, and 1·5 ml are 0·016, 0·031, and 0·047 ml, respectively. Therefore total gas contents obtained by the simplified equipment would be expected to contain a negative error arising from water condensation during compression in the volumetric tube. However, repeated experiments in which the total gas from a sample was compressed to various volumes at various pressures up to 1 atm, gave values for the total gas to within 0·01 ml NTP; condensation errors were therefore negligible. Apart from the possibility of supersaturation, the absence of condensation may have



3 *Comparison of results obtained using the normal and simplified vacuum heating equipments*

arisen from the reduction of water vapour by iron. Thermodynamic calculations show that the ratio p_{H_2O}/p_{H_2} is too low for reduction to occur at 650°C but such a reaction could occur at lower temperatures while the steel specimen is cooling.

Figure 3 shows the correlation between the total gas contents of the steel samples using the two vacuum techniques and includes a calculated line of best fit using the normal vacuum heating procedure as the independent variable. The equation for this line is

$$y = 1{\cdot}02x - 0{\cdot}15$$

where x and y are the normal vacuum heating procedure and simplified procedure, respectively.

For comparison purposes, Fig.3 also contains data obtained by Bjerkerud[2] using a similar simplified vacuum heating unit. The steel samples (plain carbon and low-alloy steel) were obtained using a copper notched pencil mould; their size, although not specifically stated, was probably about $\frac{1}{2}$in dia. × $\frac{1}{2}$in long (sample weight, 10–12 g). While it is impossible to comment specifically on the errors involved, the simplified equipment exhibited a mean negative error in agreement with the results of the present investigation.

CONCLUSIONS

1. A simplified vacuum hot-extraction procedure is described for determining the total gas evolved from plain carbon steels. Providing the apparatus is cleaned regularly and the recommended procedure adopted, total gas contents determined by this procedure (in the range 1–7 ml/100 g) should not differ by more than 0·3 ml/100 g from those determined by the normal vacuum heating procedure. The hydrogen content of the steel sample is calculated assuming the total gas to contain 90–95%H.

2. A systematic error due to residual solubility (averaging 0·06 in 1/100 g) is caused by the use of the simplified equipment and is contained within the maximum difference of 0·3 ml/100 g.

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TABLE VIII Average values and estimated maximum errors of pressure, volume, weight, and temperature readings

Variable	Symbol	Normal equipment Average value	Normal equipment Max. error	Simplified equipment Average value	Simplified equipment Max. error
Pressure (mm)	P	57	1·0	570	1·0
Volume (ml)	V	10	0·003	1·0	0·01
Weight (g)	W	15	0·0004	15	0·0004
Temp. (°K)	T	298	1·0	298	1·0
Blank pressure (mm)	P_b	130	1·0	460	1·0
Blank volume (ml)	V_b	0·6	0·003	0·05	0·01
Blank temp. (°K)	T_b	298	1·0	298	1·0

APPENDIX

Maximum difference between the results of the normal vacuum heating method and the simplified procedure due to random errors from pressure, volume, weight, and temperature readings only.

The total gas content of a steel sample is calculated from the following equation

$$y = \frac{2730}{76W}\left(\frac{PV}{T} - \frac{P_bV_b}{T_b}\right)$$

where y=total gas content (ml NTP/100 g), W=sample weight (g) P, P_b=pressures (mm Hg) for the sample and blank respectively, V, V_b=volumes (ml) for the sample and blank respectively, T, T_b=temperatures (°K) at which gas readings are taken for sample and blank respectively.

In order to assess the influence of say, P variation on y, while maintaining the remaining independent variables constant, it is necessary to find the partial differential coefficient of y with respect to P.

$$\text{Thus}\frac{\partial y}{\partial P} = 35{\cdot}92\,\frac{V}{TW}$$

If Δy is the finite change in y accompanying a small finite change ΔP in P (the other variables remaining constant), then

$$\Delta y \simeq \frac{\partial y}{\partial P}\Delta P = 35{\cdot}92\,\frac{V\Delta P}{TW}$$

Thus if the maximum error ΔP likely to occur in the pressure reading P is known, it is possible to calculate the error it produces (Δy) in the total gas content y. In a similar manner the errors in y arising from maximum errors in V, W, T, P_b, V_b, and T_b may be deduced. The maximum error in y arising from these sources acting simultaneously is that occurring when the errors arising from ΔP, ΔV, etc., are all of the same sign; it is therefore obtained by adding together the individual Δy values.

Table VIII lists average values of pressure, volume, temperature, and weight readings together with the maximum errors likely to occur when using the normal vacuum heating procedure and the simplified technique. When these data are used in the above calculation, the maximum error in the total gas content by either vacuum method is found to be 0·107 ml/100 g. The maximum difference between the two techniques owing to random pressure, volume, weight, and temperature errors is therefore 0·21 ml/100 g.

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Metallographic investigations of ancient iron objects from the territory between the Oder and the basin of the Vistula river

Jerzy Piaskowski

SYNOPSIS

Metallographic methods have long been applied to investigations of ancient iron objects. Early articles describing this kind of investigation appeared in 1912.[1] However, during the following 35 years the number of investigations was limited[2]; recently rather more articles on this topic have been published.[3] The number of ancient iron objects generally described was rather small: the authors usually examined only a few objects. Moreover, the investigations were often limited to metallographic observations only, no other laboratory methods being applied. This kind of investigation was not capable of determining the origin of objects examined nor even of evaluating the quality of the metal.

For this purpose it was necessary to examine a large number of objects. Kolzin[4] was the first to carry out detailed investigations: in his work on the metallurgy of iron in Russia in the 9th–14th centuries, he described 286 objects from 32 sites. In other work[5] he examined 276 iron objects from Novgorod (10th–16th centuries), and also carried out measurements of microhardness, hardness, spectrographic analysis, and X-ray examination of certain objects.

Systematic examination of a large number of ancient iron objects, found between the Oder and the basin of the Vistula river, has been carried out since 1955 by the Science History Committee of the Polish Academy of Science, one of the industrial research institutes. The investigation, not yet complete, has so far been concerned with 729 ancient objects from 144 sites, mainly from the 8th century B.C. to the 14th century A.D. The paper presents only a short summary of this investigation with some more interesting results. More detailed data are to be found in the enclosed bibliography. 1824

IMPORTANCE OF METALLOGRAPHIC INVESTIGATIONS OF ANCIENT IRON OBJECTS FOR THE HISTORY OF METALLURGY AND FOR ARCHAEOLOGY

METALLOGRAPHIC INVESTIGATIONS provide the main source of information about metal and the method of manufacture in antiquity. Except for a few remarks by some ancient authors[6] and the famous work by Theophilus[7] from the 11th to 12th centuries, the first more detailed written sources of information on the old technological processes appear *c.* 16th century.[8]

Metallographic investigations make it possible to ascertain with accuracy the kind of metal produced, to evaluate its quality, and to examine various ways of toolmaking used in different ancient production centres. It is also possible to determine the development of ancient technology by finding where and how certain processes, e.g. carburization, heat-treatment, and welding (joining) of iron and steel by forging, have developed and expanded. The investigations described here have revealed also certain general rules of the development of the ancient metallurgy of iron.

In antiquity, the early ironmakers did not know how to control the reduction process of iron ores, and carburization occurred accidentally, depending on the kind of ore, and the construction of the furnace. The product of smelting was very unevenly carburized iron. This seems to invalidate the suggestion by Carpenter and Robertson[9] that the iron era began at the moment of discovery of the cementation process, which permitted a metal harder than brass, because well carburized metal may have been obtained from ores occasionally long before. Later, the ironmakers mastered the process of carburization during the smelting of ore and produced, according to requirements, either soft iron or steel. The carburization of tools, cementation, was developed. This process was probably derived from the metallurgy of gold and silver, where 'cementation' was used to purify these metals. The ancient authors considered steel production from iron as a purification of metal.[10] When they had learned to distinguish iron from steel and were capable of producing either metal at will, the process of welding iron and steel was developed. This was widely used in the manufacture of tools: the working parts, edges of knives and axes were made of steel, and the remaining parts of soft iron. The tools were subsequently heat-treated.

Metallographic investigations are equally important for archaeology and for the history of the development

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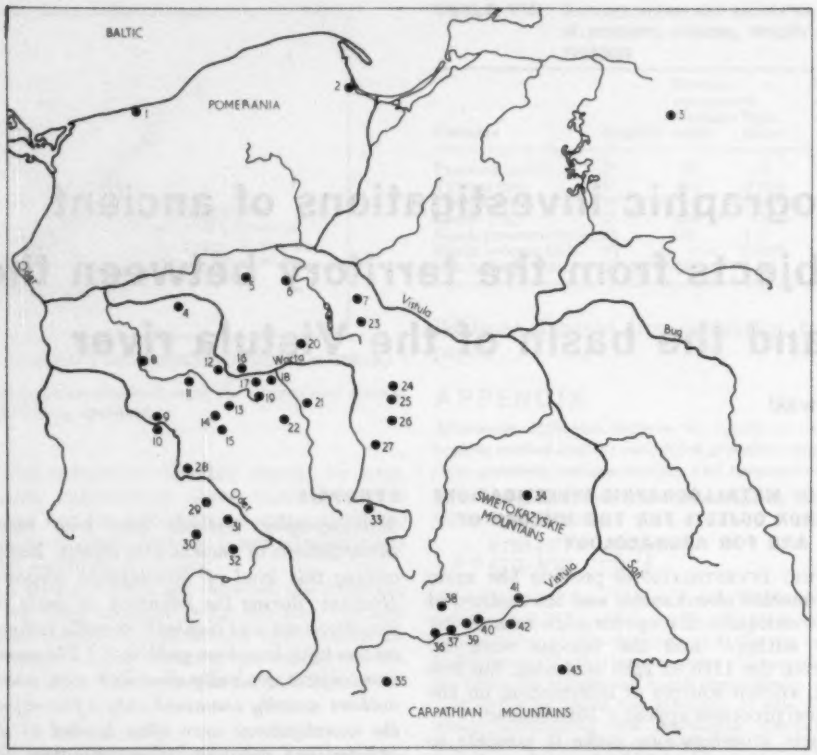


1 Kolobrzeg *2* Gdańsk *3* Szwajcaria, near Suwalki *4* Gorszewice, near Szamotuly *5* Podlesie-Koscielne, near Wagrowiec *6* Biskupin, near Znin *7* Goplano, near Aleksandrow *8* Kobienice, near Wolsztyn *9* Serby, near Glogow *10* Nosomice, near Glogow *11* Czacz, near Koscain *12* Manieczki, near Srem *13* Wymystowo, near Gostyn *14* Domaradzice, near Rawicz *15* Chojno, near Rawicz *16* Mlodzikowo, near Sroda *17* Szczonow, near Jarocin *18* Przybyslaw, near Jarocin *19* Siedein, near Jarocin *20* Slupema, near Konin *21* Skrajna, near Kalisz *22* Sobotka, near Ostrow *23* Zglowiaczka, near Wloclawek *24* Tum, near Łeczyca *25* Czerchow, near Łeczyca *26* Lutomiersk, near Łask *27* Buczek, near Łask *28* Tarchalice, near Wolow *29* Karnecza, near Wroclaw *30* Jezierzyce, near Dzierzoniow *31* Sobocisko, near Olawa *32* Glowmin, near Strzelin *33* Wasosz, near Klobuck *34* Wachock, near Ilza *35* Wegierska Gorka, near Zywiec *36* Piekary, near Krakow *37* Wawell (Krakow) *38* Iwanowice, near Miechow *39* Wyciaze, near Krakow *40* Igolomia, near Proszow *41* Witow, near Pinczow *42* Jadowniki Mokre, near Dabrowa Tavnowska *43* Wietrzno-Bobrka, near Krosno

1 *Map of the territory between the Oder and the Vistula basin showing the places where the objects described in this work were found*

of early communities. The origin of various metallic objects can be determined and thus trade and commercial relations among ancient tribes are revealed, and also the degree of knowledge and the capabilities of early craftsmen. Hitherto archaeologists determined the origin of iron objects on the basis of their shape. Conclusions drawn from this are often erroneous. An ancient smith could easily copy the shape of an object, but it was much more difficult for him to obtain the same composition of the metal for a number of objects and to apply identical technology. For example, some Celtic swords, frequently of similar shape, were found to exhibit different methods of production[11] thus indicating different places of origin.

If the development of iron technology in a certain region is known, it is possible in certain cases to determine the period of origin of the objects found, even if no other archaeological material, which would help date the object, is available. Metallographic dating cannot always be accurate since in some production centres the kind of metal produced as well as the technology, remained unchanged for several centuries.

In some cases examination may supply entirely new information for an archaeologist. For example, on the basis of some excavation work in the Swietokrzyskie Mountains, carried out by the Archaeological Museum at Krakow, it was found that an ironmaking centre existed in that region in the 2nd–3rd centuries A.D. Examination has shown that iron objects made of the same kind of metal and by the same technique appeared in the basin of the Vistula in the Hallstatt period, in particular the 6th century B.C.[12] Thus it seems that the beginning of the ironmaking period in Swietokrzyskie Mountains can be dated eight centuries earlier. Investigations also supply some general information of importance for the history of civilization, by illuminating the technical development of an early community and the influence of other communities.

CHOICE OF OBJECTS FOR EXAMINATION

Metallographic investigations require the fulfilment of three basic conditions:

(i) an adequately large number of objects to be examined
(ii) application of all modern laboratory methods of investigation; metallographic observations alone are not sufficient
(iii) expert metallurgists, specializing in this kind of work, to carry out the investigations.

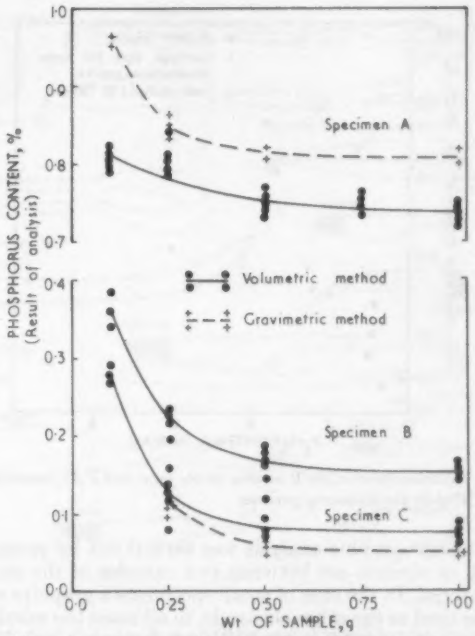
First, objects should be examined from the places where the old production centres existed. This should be accompanied by examinations of ores, slags, and fragments of semi-finished products. In order to apply statistical analysis to the results of investigations, objects should be chosen at random. In the investigations described, however, this method of selection was impractical, for two reasons. First, results of investigation are not of uniform importance for all kinds of objects. Most interesting results are obtained on the basis of examination of hardened tools such as knives and shears as well as some arms, such as swords. No hardening was applied to objects such as nails, rivets, horseshoes, stirrups, spurs, and arrow heads, and the results of their examination are less important. On the other hand, archaeologists require some objects, owing to their beauty, in the undamaged state for museum display. Therefore the choice of objects should be agreed between a metallurgist and an archaeologist. Most of the objects should be tools and parts of arms; however, other commonly used objects such as nails and rivets should not be ignored.

The number of objects chosen for examination depends on (*a*) the total number of objects found at a given site, (*b*) the variety of techniques encountered, and (*c*) the knowledge of the technology of iron objects in a given period. The number of objects can be influenced by the variety of techniques of production; if the technology of some of a certain period is known, the number of objects required may be less. During investigation of material from some ancient cremation tombs, 1st–3rd century A.D., in the middle of the Warta basin, 60 objects were enough for examination, as the majority of objects came from one production centre in the Swietokrzyskie Mountains. During another investigation, of material from Gdańsk, greater technological variety of objects was encountered (10th–14th centuries), but the 106 objects examined, with additional superficial examination of 39 knives, gave only enough information to draw some general conclusions.[13]

METHODS OF INVESTIGATION

Iron objects chosen for investigation were photographed and weighed, and drawings were prepared on which the positions of the specimens cut out for tests were marked. For some objects (e.g. socketed axes), gamma-radiography was used to determine the technique of their manufacture. The Co^{60} isotope was employed, although somewhat better results can be expected by the use of Ir^{192} owing to the softer gamma radiation emitted by this isotope.[14]

In the case of tools made by welding iron and steel bars together, some auxiliary surface examination was carried out to determine the direction of the iron and steel layers.[15] Part of the tool surface about 1 cm long, was cleaned from rust and etched alternately with concentrated nitric acid and 4% solution of nitric acid in methyl alcohol, each etching lasting from several s to about 1 min. After 1–3 min, regions of greater carbon (carburized layers or steel) became dark (Figs.46 and 51). Similar results were obtained by Kolchin[5] who etched with 25% solution of hydrochloric acid in water. Time of etching lasted from 5 min to 1 h. Specimens were usually cut from the working parts of tools (e.g. edges of axes, knives, and sickles), but in some cases also from other parts (e.g.

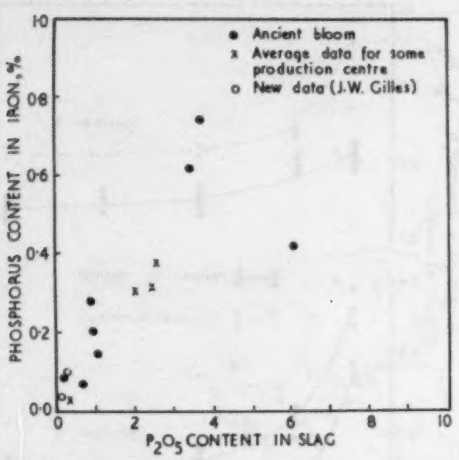


2 *Effect of specimen weight on results of analysis (volumetric and gravimetric) for* P, *in several samples of bloomery iron*

knife handles, spear sockets, and hilts of swords).[16] For objects such as nails and rivets the location of a specimen has no particular importance. Specimens for microscopic examination were always prepared parallel (some also perpendicular) to the direction of estimated technological processes, e.g. carburization, and quenching (for heat-treatment). Specimens were mounted either in Wood's alloy or in methyl methacrylate; bakelite can also be used.

Earlier authors took specimens from the surface of objects.[9, 17] This method does not give accurate results since the internal structure of an object is not revealed. Under these circumstances it is not possible to distinguish whether the surface carburization observed is the result of a deliberate cementation process, or whether it has taken place accidentally during smelting of ore in a bloomery furnace. It could not, therefore, be certain whether ancient Egyptian objects (12th–8th centuries B.C.) examined by Carpenter and Robertson[9] had been subjected to the cementation process by the maker, or had been made of unevenly carburized iron.

To reveal the structure of metal in specimens, they were usually etched in 4% solution of nitric acid in methyl alcohol, a reagent which is also effective in revealing phosphorus microsegregations. The grain size was determined using the ASTM scale. Microhardness measurements were carried out on a Hanemann's apparatus, 50 g load being applied for iron or soft steel and 100 g load for hard steel, for 15 s. Each result was an average of five indentations. Hardness was measured by the Vickers method; specimens were placed in a small vice and a load was applied for 15 s to the indenter placed on the specimen; 10 kg load was used for iron and soft steel and 30 kg load for hard steel. The number of indentations depended on the specimen size and was usually 2–4.



3 *Relation between the* P *content in the iron and* P_2O_5 *content in slag in the bloomery process*

Spectrographic analysis was carried out by producing an electric arc between two samples of the same material. In the case of small specimens a graphite rod was used as the other electrode, in all cases the middle-dispersion spectrograph ISP–22 being employed. The presence of an impurity clearly indicated by the spectrograph was denoted by the symbol + in the tabulated results of spectrographic analysis, while the symbol o was used for evidence of an impurity on the basis of a few strongest lines of the spectrum. For some impurities, e.g. As, Co, Mo, Sb, Sn, Ti, it was found that the results of the spectrographic analysis were not always reproducible.

Classical methods of chemical analysis were used. From the point of view of the quality and of the origin of iron or steel objects examined, the analyses for phosphorus were of greatest importance. The results of these analyses by both volumetric and gravimetric methods tended to be higher for small-weight samples, as shown in Fig.2; samples weighing at least 1 g gave results independent of the weight. The observed relation is rather difficult to explain. It seems that in the volumetric method some excess quantity of nitric acid is necessary, in presence of phenolphtalein, to change the colour of solution. This excess contributes the additional phosphorus content in the sample: it is greater the lower the weight of the sample and the lower the P content. The photometric method, used for determination of smaller P content (0·25%P or less), may be used with smaller samples of about 0·4 g.

The P content in ancient iron is of great importance in the investigation of archaeological materials. It indicates not only the quality of iron, but simultaneously the kind of ore used for the smelting of metal. The investigation shows that the P content in the metal was correlated with the quantity of this element in the slag, i.e. in the ore. Figure 3 presents the relationship between the P content in the blooms and the P_2O_5 content in the slag removed from the same pieces. In Fig.3 the average values of analyses of iron and slag from some medieval production centres are also included.

Other impurities determined were silicon and manganese, and in some cases also nickel, sulphur, and copper. Silicon and manganese do not usually exceed 0·1%, the former impurity appearing mostly as slag inclusions. The sulphur content found in iron objects was usually very small (below 0·03%), except when the ore contained some pyrites impurities, e.g. an object (13th century) found near Gdańsk contained 1·06%S.[14] The presence of nickel in some objects does not fully support the view[18] that the metal of the objects was of meteoric origin. It is possible that some nickel present in the ore might enter the metal during smelting.

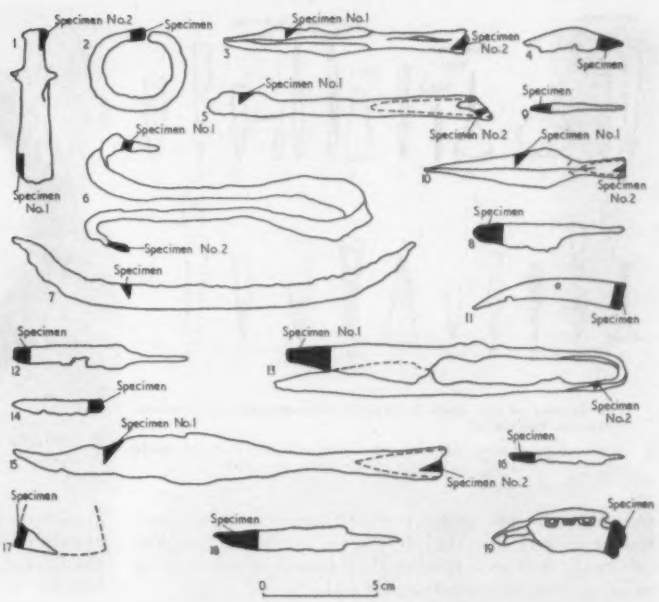
The carbon content was determined only roughly on the basis of metallographic observations. The objects to be examined were usually preserved in paraffin wax, and the analyses for carbon were liable to large errors. Washing of the objects in benzene and in methyl alcohol reduced the error but could not eliminate it, and it remained of large magnitude. Also a number of iron objects showed uneven carburization, and determination of some average C content would not have had any real significance as it would have been a purely local figure. It was pointless to determine C content in cemented tools.

Investigations should be supplemented by chemical analyses of raw materials, e.g. ore, charcoal, and slag; the determination of the melting points of slags is useful. If authors carrying out metallographic examinations of ancient objects used similar methods to those described this would facilitate comparison of the results and the formulation of general conclusions. Some published work omits very important details; documentation of the results is thus incomplete. Results should be accompanied by description of methods of examination. Rough drawings of objects examined should be included, indicating the places

TABLE I Results of chemical analysis of ores and slags from ancient iron production centres

No.	Object	Locality	Period	Chemical analysis, % Fe	FeO	Fe_2O_3	SiO_2	CaO	MgO	P_2O_5	Al_2O_3	MnO	S
1	Slag	Siedlemin, nr. Kepno	4th–1st cent. B.C.	54·85			13·50	1·75	0·17	6·02	2·13	0·28	0·17
2	Slag	Wyciąże, nr. Krakow	2nd–1st cent. B.C.	53·39*	55·24	14·73	18·85	2·71		1·37	1·56		0·08
3	Slag	Tarchalice, nr. Wolow	1st–4th cent. A.D.	48·16			25·45	0·92	0·19	1·61	4·30	0·21	0·08
4	Slag	Gora Chelmowa nr. Nowa Slupia	1st–4th cent. A.D.†	50·07*	56·75	4·7	25·14	1·42	0·86	0·18	3·22	1·57	0·48
5	Slag	Czacz, nr. Koscian	1st–4th cent. A.D.	44·54			29·60	0·97	0·17	0·19	2·00	0·20	0·19
6	Slag	Igolomia, nr. Proszowice	2nd–4th cent. A.D.	56·12†	57·26	16·37	17·46	2·43		2·85	1·06		0·09
7	Slag	Czerchow, nr. Leczyca	9th–10th cent. A.D.	47·86†	1·30	67·00	19·40	1·29	0·38	2·72	4·81		
8	Ore (no.1)	Tum, nr. Łeczyca	12th–14th cent. A.D.	43·70†	26·00	33·57	24·25	1·86	0·19	1·65	11·53	0·39	0·00
9	Slag (no.5)			57·70†	39·32	38·83	8·10	7·12	1·12	3·41	0·40	1·17	0·22
10	Ore	Gdańsk	14th cent. A.D.	55·64			19·26	0·62	0·19	1·08	3·38	0·36	
11	Slag	Gdańsk	13th cent. A.D.	56·40			33·69	1·43	0·17	0·99	2·76	0·60	0·21

* Calculated on the basis of FeO and Fe_2O_3 content
† Analysed by S. Holowinski: *Studia z dziejow gornictwa i hutnictwa*, 1958, **2**, 115.



1 Flat axe from Gorszewice, near Szamotuly
2 Bracelet from Manieczki, near Srein
3 Spearhead from Skrajna, near Kalisz
4 Sickle (no.1) from Biskupin, near Znin
5 Spearhead from Karncza, near Wroclaw
6 Sword, from Iwanowice, near Miechow
7 Scythe from Wyciaze, near Krakow
8 Knife (no.3) from Wymyslowo, near Gostyn
9 Pestle (no.1) from Domaradzice, near Rawicz
10 Spear from Jadowniki Mokre, near Dabrowa Tarnowska
11 Sickle from Igolomia, near Proszowice
12 Knife (no.1) from Biskupin, near Znin
13 Scissors from Szwajcaria, near Suwalki
14 Knife (no.3) from Czerchow, near Leczyca
15 Spearhead (no.7) from Lutomiersk, near Łask
16 Knife (no.6) from Wawel (Krakow)
17 Axe (no.3) from Tum, near Łeczyca
18 Knife (no.7) from Gdańsk
19 Horseshoe (no.2) from Pickary, near Krakow

4 *Schematic representation of some examined objects; places where specimens were taken are marked as dark areas*

from which specimens were taken. Microstructures should be illustrated by photographs; other results, e.g. chemical analyses, grain size determinations, and hardness and microhardness measurements should be tabulated. The technique for the production of objects should be described, together with sketches illustrating the technology of the objects in the manner first practised by Kolczin.[4] For example, in this work Tables I–VIII contain the results of examination of ore, slag, some semi-finished products, and several iron objects. Photographs of microstructures are shown. A rough drawing is shown in Fig.4 and sources of specimens are indicated. Figure 5 illustrates schematically the technology of these objects.

ELABORATION OF RESULTS

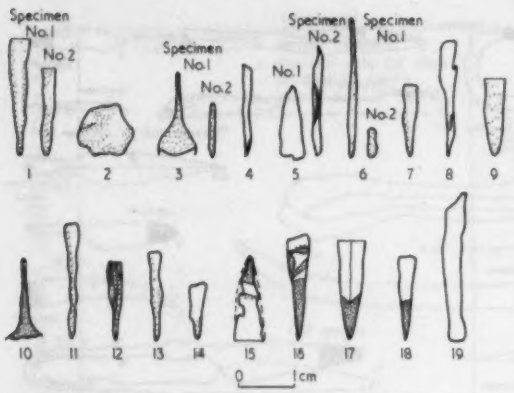
The purpose of metallographic examination is to determine the chemical and structural characteristics of the metal of an object examined, as well as its technology. It is difficult sometimes to find whether an object was made from unevenly carburized iron or from welded iron and steel, or whether it was deliberately hardened by cementation; for example, Panseri *et al.*[19] supposed that a sword from Vetulonia was welded from three layers of iron and two layers of steel, but the structure of the metal revealed no traces of welding and the sword was most probably forged from unevenly carburized iron. It is more difficult to determine the origin of the objects. For this purpose it is necessary to know the kind of the metal produced in various ancient ironmaking centres as well as the technological processes applied to the manufacture of the objects. The main difficulty in establishing the type of metal produced in different ancient centres is due to occasional variations of the chemical composition and of the metal structure. This difficulty can be resolved by examination of a large number (30–100) of objects by three methods.

The first, the 'several specimens method', is to take two to four specimens from different positions on one object; this makes it possible to determine variations of structure within the object. The second, the 'method of bounded objects', makes it possible to determine variations of chemical composition, structure of metal, and slag inclusion etc. in objects deriving from the same production centre. This method is based on the investigation of objects consisting of several different pieces of metal joined together, e.g. knives with handles fixed with iron rivets, swords made of several parts (hilt and handguard). It must be

TABLE II Results of qualitative spectrographic analysis and melting points of ores and slags

No.	Object	Locality	Melting point, °C	Qualitative analysis* As	Ba	Bi	Cr	Cu	Mo	Ni	Pb	Sb	Sn	Ti	W	V	Zn
1	Slag	Siedlemin, nr. Kepno	1270–1290	+	+	0	+	0	0	+			0	+(?)		(?)	+
2	Slag	Wyciaze, nr. Krakow	1190–1310	0	+		+	0			0			+(?)		(?)	+
3	Slag	Tarchalice, nr. Wolow	*c.*1160	+	+		+	+		+	0	0	0	+(?)		0	+
4	Slag	Czacz, nr. Koscian	1180–1310	+	+		+	0		+			0	0(?)		(?)	+
5	Slag	Igolomia, nr. Proszowice	*c.*1260	0	+		+	+		+	0		0	+(?)		0	+
6	Slag	Czerchow, nr. Leczyca	1260–1300	+	+	0	+	0		+	+		0	(?)			+
7	Ore (no.6)	...	...	(?)			+	+		+	0			(?)		0	+
8	Slag (no.5)	Tum, nr. Łeczyca	*c.*1350(?)	0	+			0		0			+	(?)		(?)	+
9	Ore	Gdańsk	...	0	+		0	+		+	0			+(?)			0
10	Slag (no.11)		1160–1330	+	+			+		+	+			(?)		0	+

* Also Fe, Si, Mn, Ca, Mg, Al, P, and S which always appear in slags. Owing to contamination of some graphite electrodes with Ti and V the detection of these elements in some specimens was not possible. In the slags 1, 3, 6, and 8 there were probable traces of Ag.



The density of the spots is roughly proportional to C concentration in the metal

5 *Technology of some iron objects examined (same objects as in Fig.4)*

6 *Bracelet from a tomb at Manieczki, near Srem (6th–4th centuries B.C.)*

remembered that some parts of objects might have been replaced or added during the period of use, and the final conclusion should, therefore, be confirmed by examination of several similar objects.

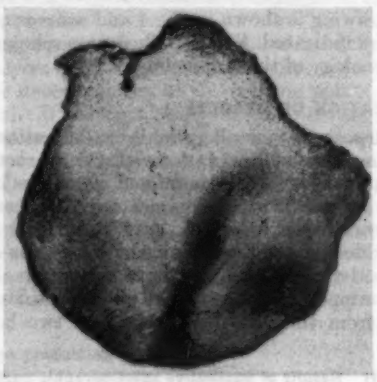
The third method used to determine the variations of metal analysis and structure is the examination of objects identical in shape. To classify the objects into groups of common origin the data concerning various metal characteristics (C and P content, grain size, and hardness) of iron objects are compiled and, if possible, analysed statistically.

Once the type of metal produced at a given locality is known, it is necessary to identify the technological processes that were applied to the production of iron objects. Particularly helpful in this case are fragments of blooms or of objects lost or rejected by the maker, as they can be regarded as being of local origin. The method of identification of iron objects deriving from a certain ancient production centre will be presented elsewhere.[20]

DEVELOPMENT OF IRON TECHNOLOGY BETWEEN THE ODER AND THE BASIN OF THE VISTULA RIVER

Iron appears first, in very small quantities, between the Oder and the basin of the Vistula river in the Fifth Bronze Age period (10th–8th centuries B.C.). A somewhat greater number of iron objects were found in this region of about 750 B.C. The inhabitants of this area, especially those occupying the middle of the Warta basin and Lower Silesia, belonged to the Lusatian culture and most of their iron objects came from production centres outside their territory. The metal of the objects is mainly unevenly carburized iron, e.g. the thick bracelets illustrated in Figs.6 and 7.[20–25] Ancient iron objects examined by other authors, have shown a similar type of metal.[26,27] Examination by Hanemann[27] of an iron bloom showed that very unevenly carburized iron was produced somewhere near the Rhine. Similar structure was identified in two iron blooms found at Witow, near Pinczow, one was examined by Krupkowski and Reyman,[28] the other by the present author (Tables III–V and Figs.8 and 9).

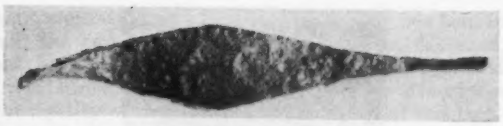
It seems that in some centres, producing unevenly carburized iron, the makers recognized the difference between hard and soft metal, and deliberately produced the edge of the tool from the more carburized part of the bloom. Some socketed axes (Fig.10) and a knife found at Slupca, near Konin (Fig.11) were also heat-treated (Fig.12). Imported objects in this area can be recognized by their more complicated technology, e.g. a cemented spearhead and a flat axe from



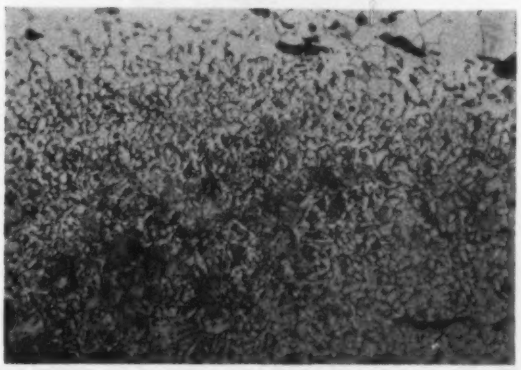
7 *Macrostructure of lateral cross-section of bracelet from Manieczki; portions more strongly carburized are dark areas; etched in nital* ×5

TABLE III Results of chemical analysis of a lump and blooms

No.	Object	Locality	Date	Weight, g	Content, % Si	Mn	P	S	Ni	Cu
1	Lump of iron	Przybyslaw, nr. Znin	6th–4th cent. B.C.	1100	0·00	0·00	0·26		0·00	
2	Bloom	Witow, nr. Pinczow	6th–1st cent. B.C.	660·0	0·14	0·056	0·049	0·020	trace	0·00
3	Bloom of steel (no.1)	Gdańsk	12th cent. A.D.	236·5	0·17	0·00	0·07		trace	
4	Bloom of iron (no.2)	Gdańsk	13th cent. A.D.	39·6	0·24	0·00	0·21	1·06	0·00	
5	Bloom of iron (no.5)	Tum, nr. Łeczyca	12th–13th cent. A.D.	567·6	0·23		0·62		0·00	

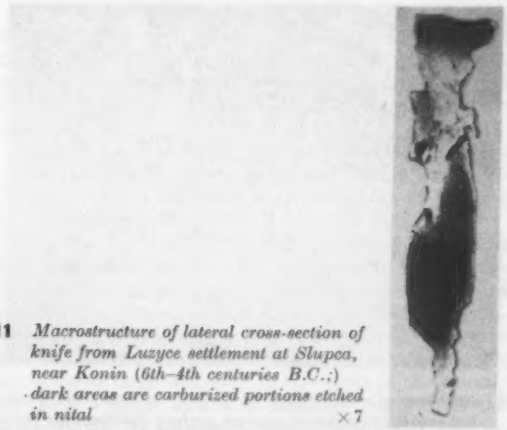


8 *Bloom of iron from Witow, near Pinczow*

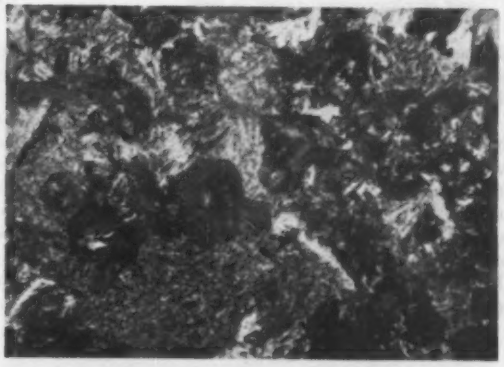


9 *Structure of bloom of iron from Witow; pearlite and ferrite; etched in nital* ×100

10 *Macrostructure of lateral cross-section of socketed axe (no.1) from the 'treasure' at Szczonow, near Jarocin (6th–4th centuries B.C); dark areas are carburized portions; etched in nital* ×7



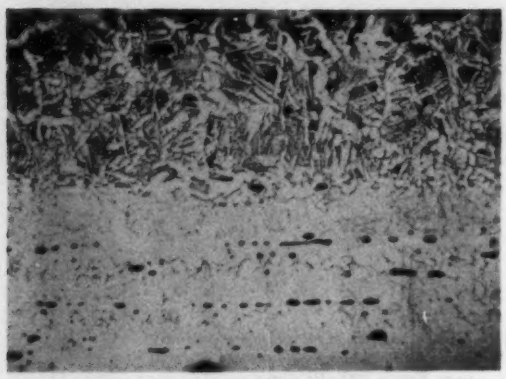
11 *Macrostructure of lateral cross-section of knife from Luzyce settlement at Slupca, near Konin (6th–4th centuries B.C.;) dark areas are carburized portions etched in nital* ×7



12 *Structure of carburized portion of knife from Slupca; troostite; etched in nital* ×500

13 *Macrostructure of spearhead leaf from a tomb at Gorszewice, near Szamotuly (7th–6th centuries B.C.); dark areas are carburized parts; etched in nital* ×4

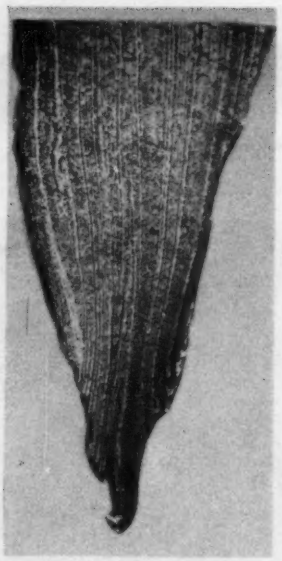
14 *Macrostructure of lateral cross-section of chisel edge from a tomb at Chojno, near Rawicz (7th–6th centuries B.C.); dark area is a layer of steel; etched in nital* ×3



15 *Structure of chisel edge from Chojno; in steel portion* (top) *are pearlite and ferrite; in iron portion* (bottom) *are ferrite and slag inclusions; etched in nital* ×100

Gorszewice, near Szamotuly (Fig.13), and a chisel (iron and steel welded together) from Chojno, near Rawicz (Figs.14 and 15).[20]

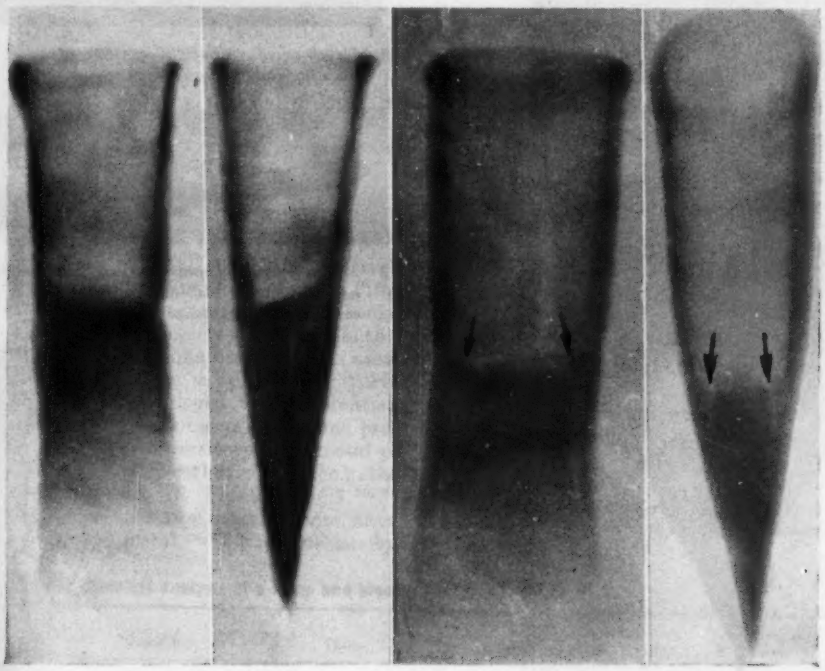
Characteristic implements for the Hallstatt period (8th–4th centuries B.C.) are socketed axes. Gamma-ray investigation showed that they were either forged from one piece of iron, one end being flattened and turned into a socket (Fig.16*a*), or a separate iron socket was pressed on to a blade made of steel or cemented iron, and both parts welded together (Fig.16*b*). An interesting technology is shown by the socketed axe from Wietrzno-Bobrka, near Krosno,



17 *Macrostructure of lateral cross-section of the socketed axe edge from Jezierzyce, near Dzierzoniow (6th–4th centuries B.C.); laminated structure; etched in nital* ×10

consisting of layers of low-carbon steel welded together with high-nickel iron.[29]

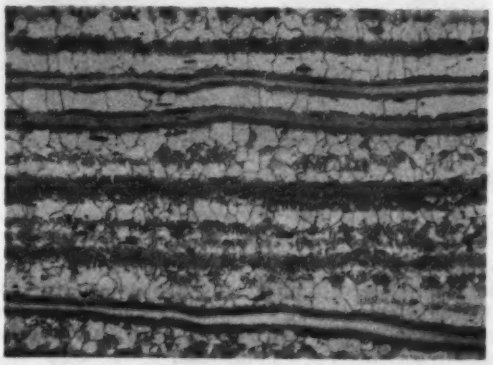
Some objects made by the so-called 'packeting technique' were also probably imported. In this tech-



a b

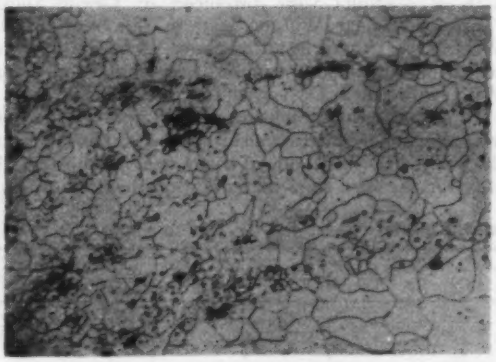
16 (a) *Gamma-radiograph of socketed axe from Kobienice, near Wolsztyn (6th–4th centuries B.C.); forged from one piece of metal*
(b) *Gamma-radiograph of socketed axe from Szczonow, near Jarocin (6th–4th centuries B.C.); separately made socket was pressed on to the blade*

nique a piece of metal flattened by forging was bent in half; the two parts were welded together, flattened, and bent again. The process, which was repeated several times, may have caused the increase of hardness and rigidity of the metal. Two examples of this technique are illustrated: a steel axe from Jezierzyce, near Dzierzoniow (Figs.17 and 18),[23] and a similar iron axe from Biskupin, near Znin (Fig.19).[24]



18 *Structure of socketed axe from Jezieirzyce; layers of sorbitic pearlite, ferrite, traces of welding; etched in nital* ×100

19 *Structure of socketed axe edge from the Luzyce settlement at Biskupin, near Znin (6th–4th centuries B.C.); ferrite, precipitation of α″–$Fe_{16}N_2$ and slight slag inclusions, welding seams; etched in nital* ×100

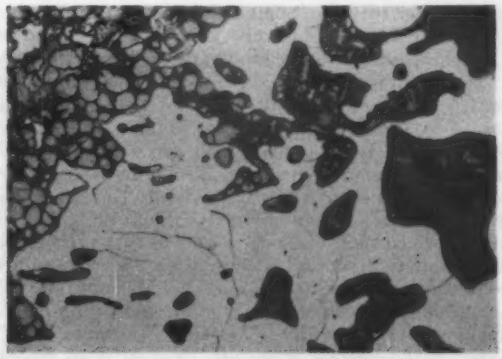


20 *Structure of sickle (no.1) from Luzyce settlement at Biskupin (5th century B.C.); ferrite and slag inclusions; etched in nital* ×100

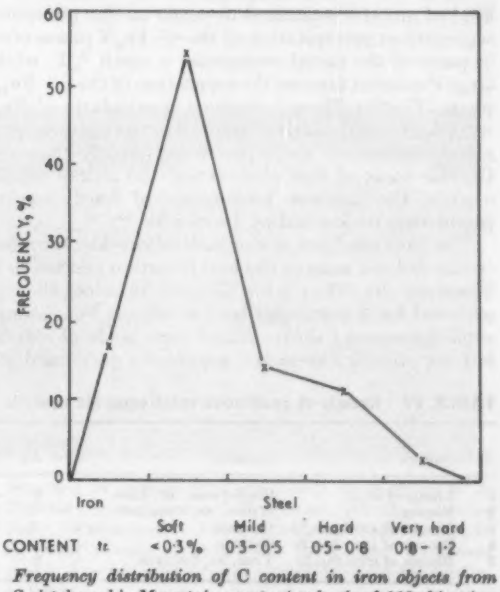
Some objects made of soft bloomery iron (ferritic structure) may have been produced in the basin of the Warta river or in Lower Silesia, most probably from the local bog ores. The tools produced were not even hardened; a sickle (no.1) from Biskupin is shown (Fig.20).[21]

In some cases, however, the people of the Lusatian culture made iron objects from imported raw materials; this view is supported by some lumps of iron found (Biskupin. Fig.21).

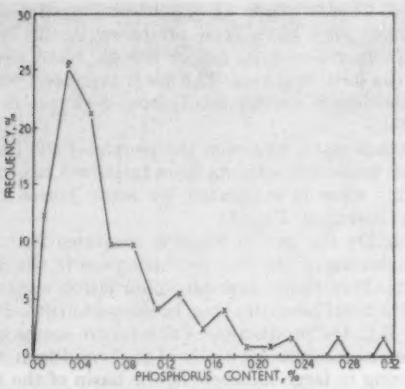
Probably the period 7th–6th centuries B.C. marks the beginning of the iron-producing era in the Swietokrzyskie Mountains. Low-phosphorus iron was smelted from the local hematite ores. In the period 6th–4th centuries B.C. the production of this centre seems to have been considerable. All kinds of tools and iron objects appearing in large numbers in the basin of the middle and lower Vistula, and in Pomerania, came from the above centre. At about the 3rd century B.C. these objects also spread over the territory of the Warta basin,



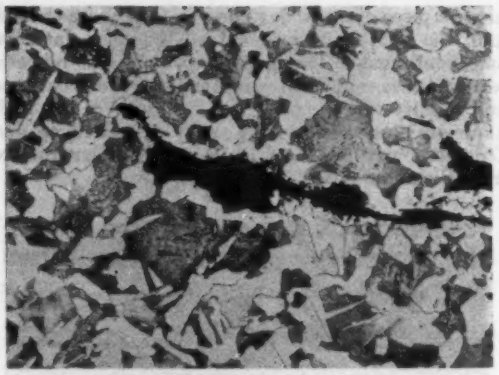
21 *Structure of a lump of iron from the 'treasure' at Przybyslaw, near Jarocin (6th–4th centuries B.C.); ferrite, strong slag impurities; etched in nital* ×100



22 *Frequency distribution of C content in iron objects from Swietokrzyskie Mountains centre (on basis of 118 objects)*



23 *Frequency distribution of* P *content in iron objects from Swietokrzyskie Mountains centre (on basis of 122 analyses)*



24 *Structure of spearhead from a tomb at Skrajna, near Kalisz (6th–4th centuries B.C.); pearlite, ferrite, some slag inclusions; etched in nital* ×100

and later they even reached northern Italy, having been carried over by Celts. Some Celtic swords examined by C. Starrti and M. Mariani[30] and C. Panseri and M. Leoni[31] exhibit the same kind of metal and technology.

The metal produced in the Swietokryskie Mountains centre had a rather wide range of C content, from traces to about 0·8% or more (Fig.22), and a small %P (Fig.23). In this area pyritic ore was side by side with hematitic ore, but the ancient miners knew how to distinguish them and explored only the latter. Yet in spite of this a bloom of high S content (0·225%) was observed. In many objects found in tombs there is a characteristic structure of metal from the above centre, consisting of pearlite and ferrite (Figs.24 and 25) and sometimes cementite (Fig.26), depending on the degree of carburization. The slag inclusions have a dark, homogeneous structure (Figs.24 and 25). In less carburized portions separation of nitrides, probably γ'–Fe_4N and α''–$Fe_{16}N_2$, may occur (Fig.27). Similar inclusions in iron and steel were determined by Brooker *et al.* as the above compounds.[32] It seems that the kind of nitrides separated depends on the phosphorus segregation; precipitation of the γ'–Fe_4N phase occurs in parts of the metal containing a small %P, while a large P content favours the separation of the α''–$Fe_{16}N_2$ phase (Fig.28). These inclusions, particularly γ'–Fe_4N, were paths of oxidation; thus the iron containing the nitride inclusions could rust more quickly than steel. On the basis of this observation the author tried to explain the ancient technology of hard iron/steel production mentioned by Diodor Sic.[33]

The iron smelters in the Swietokrzyskie Mountains centre did not master the carburization process in the bloomery fire. They were not able to select the right material for a particular tool or object. For example, some knives and shears found were made of soft iron but for objects like spurs, sometimes very hard steel was used. It is not certain whether the ironmakers of the above centre applied any heat-treatment. The objects of this period were mainly found in ancient tombs, and firing in pyres had removed any traces of heat-treatment. The examination of the tools more recently examined, probably deriving from the same centre of production, found in an ancient settlement at Wasosz, near Klobuck (Fig.29), suggests the application of heat-treatment by the smiths in the Swietokrzyskie Mountains. From the Swietokrzyskie Mountains production centre came also some objects found in Celtic tombs near the Vistula (a sword made of soft steel, from Iwanowice, near Miechow) and in Lower Silesia (a spearhead and knife from Sobocisko, near Olawa). Celtic swords found in Lower Silesia were made of hard steel (a sword from Sobocisko is shown in Fig.31). Five Celtic spearheads from the same area were forged from bloomery iron, having a high P content (a spearhead from Karncza, near Wroclaw is shown in Fig.32).

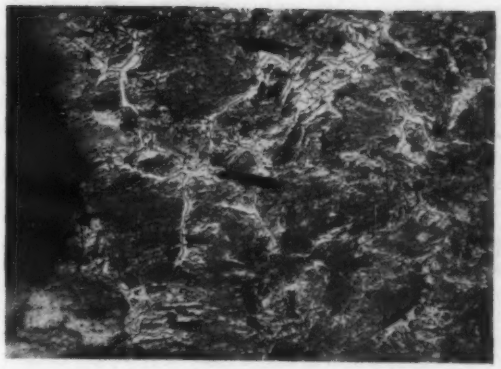
The earliest ironmaking furnaces, dated from ceramic material by the archaeologist from the La Tène period (4th–1st centuries B.C.) are found at Siedlemin, near Jarocin, and at Zglowiaczka, near Wloclawek; the latest excavations showed that the furnaces in Tarchalice, near Wolow (Tarxdorf) belong to the Roman period (4th–1st centuries B.C.). In the La Tène period, some rather small quantities of iron (with high P content) were produced in Lower Silesia (Tarchalice, near Wolow), and in the basin of the Warta river; there is no evidence of hardening processes having been applied (*see* knife no.3 from Wymyslowo, near Gostyn in Tables VI–VIII).

In about the 2nd century B.C. a number of small iron-producing centres appeared between the Oder and the Vistula basin. In one of them, near Krakow, probably for the first time carburization, heat-treatment,

TABLE IV Results of qualitative spectrographic analysis of a lump and blooms

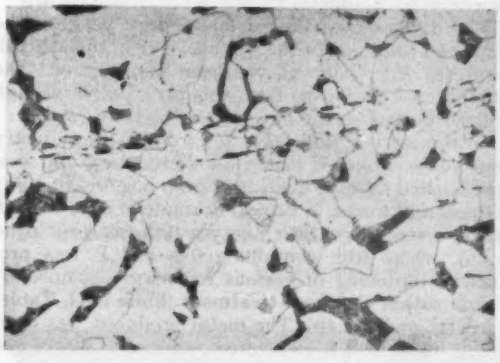
No.	Object	Locality	Qualitative analysis* Al	As	Ba	Bi	Ca	Co	Cu	Mg	Ni	Pb	Sb	Sn	Ti	V	Zn
1	Lump of iron	Przybyslaw, nr. Znin	+	0	0	+	+		+	+	+	+		+	0		0
2	Bloom	Witow, nr. Pinczow	+	+	0	0	+		0	+	+	0		+	0		+
3	Bloom of steel (no.1)	Gdańsk	+	+	0	0	+		+	+	+	0		+	+		0
4	Bloom of iron (no.2)	Gdańsk	+	+	0	0	+		+	+	+	+		0	+	0	+
5	Bloom of iron (no.5)	Tum, nr. Łeczyca	+	0	+	0	+		0	+	0	+		+	?	?	+

* Also Fe, Si, Mn, P, and S which are always present in the bloomery iron. In objects 1, 2, and 5 there are probable traces of Ag.



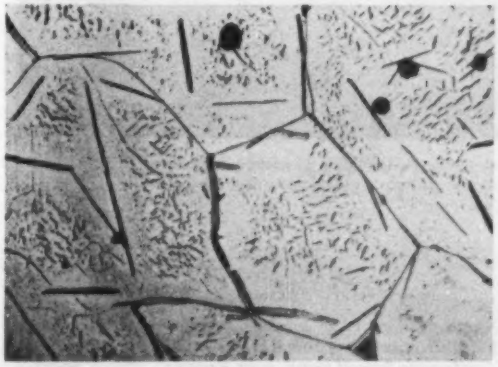
25 *Structure of spearhead (no.3) from a tomb at Jadowniki Mokre, near Dabrowa Tarnowska (2nd century A.D.); pearlite, hypereutectoidal cementue and slag inclusions; etched in nital* ×100

28 *Phosphorus segregation and precipitation of the γ′–Fe_4N phases in the scissors from Serby, near Glogow; dark areas are places with low P content; etched with Fry's reagent* ×500

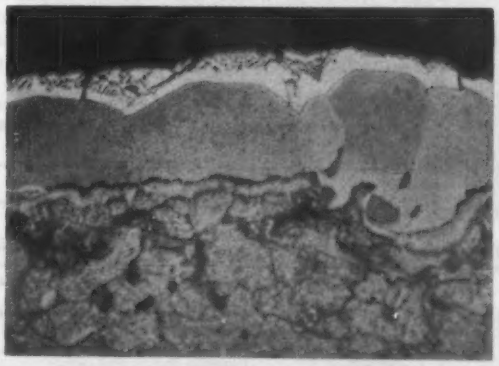


26 *Structure of spearhead from a tomb at Mlodzikowo, near Sroda (2nd–3rd centuries A.D.); ferrite, pearlite, and slag inclusions; etched in nital* ×100

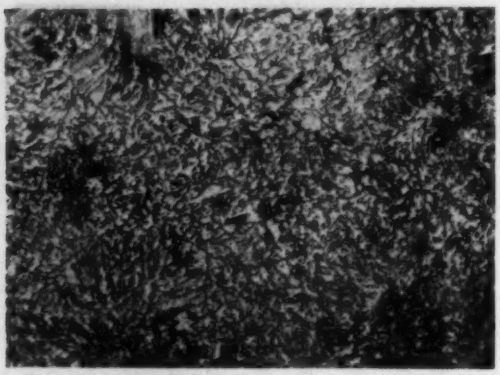
29 *Structure of sickle (no.4) from Wasosz, near Klobuck (3rd–4th centuries A.D.); acicular troostite, ferrite at grain boundaries, and some slag inclusions; nital* ×500



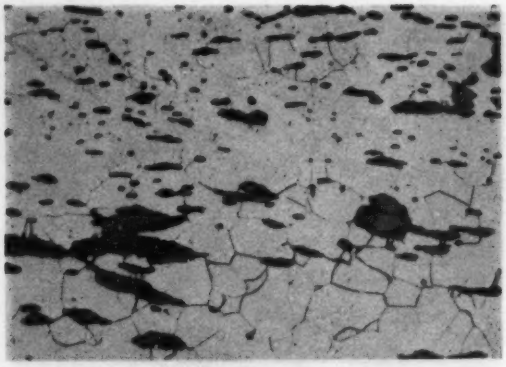
27 *Structure of needle from Nosocice, near Glogow (1st–3rd centuries A.D.); precipitation of acicular phase γ′–Fe_4N and traces of α″–$Fe_{16}N_2$ nital* ×500



30 *Structure on surface of a pin (no.2), from the tomb at Podlesie Koscielne, near Wagrowiec (6th–4th centuries B.C.); in iron portion* (bottom) *are pearlite and ferrite; in the brass portion* (top) *α-phase (dark) and δ-eutectoid (light); etched in nital followed by etching in alcohol solution of* $FeCl_3$ ×100



31 *Structure of sword from Celtic burial ground at Sobocisko, near Olawa (2nd–1st centuries B.C.); sorbitic pearlite; etched in nital* ×500



32 *Structure of spearhead from Celtic burial ground at Karncza, near Wroclaw (4th–2nd centuries B.C.); ferrite and slag inclusions; etched in nital* ×100

and welding of iron and steel were applied (a scythe from Wyciaze, near Krakow, 2nd–1st centuries B.C.; Igolomia, near Proszowice, 2nd–4th centuries A.D.; *see* Figs.33 and 34).[34] The knowledge of these processes probably came from Bohemia, where some Celtic iron-making centres had existed for some time: (Lhotice, Stradonice).[35] The iron produced near Krakow was smelted from bog ores and had a high P content (0·25–0·50%P).

Another ancient type of iron has been identified in the north-eastern part of Poland, in the 3rd–4th centuries A.D. Investigations of iron objects from tombs at Szwajcaria, near Suwalki, showed that the metal was soft iron containing about 0·1%P (Tables VI–VIII). Hardening was probably obtained by carburization and heat-treatment (e.g. the shears in Fig.35). It seems that these objects were imported.[36]

A rather interesting technique was observed in the case of a few objects of the same period but of an unknown origin, presumably imported, e.g. a knife, from an old settlement at Biskupin, near Znin (3rd–4th centuries A.D.), was welded from carburized and twisted iron rods, followed by quenching (Figs.36 and 37).

The technology of two swords from Sobotka, near Ostrow and Wachock, near Ilza (3rd–4th centuries A.D.), is rather difficult to identify. Strongly carburized layers (steel) have been observed, in the metal structure, as well as soft iron layers (Fig.38); traces of slag indicate the application of the welding process (Fig.39). The distribution of iron and steel layers in both swords is different from that in the swords from Nydam described by Schürmann,[37] but similar to that described by Neumann.[38]

The development of iron metallurgy between the Oder and the basin of the Vistula river in the 4th–9th centuries A.D. has not yet been investigated. The number of iron objects from this period is very small and archaeologists are uncertain as to their date.

In the early Middle Ages the ironmaking industry was well established in the above territory and iron was smelted in small quantities from bog ores in many villages and towns. A typical example of such a small centre is Czerchow, near Łeczyca (9th–10th centuries A.D.), where iron containing 0·2–0·4%P was produced. Hardening of various tools was obtained by carburization and heat-treatment (knife no.3, Tables VI–VIII and Fig.40). The metal produced was commonly used for making knives, shears, sickles, keys, awls, axes, spearheads, and swords.

Simultaneously a new kind of technology appeared on the above territory, first encountered in objects

TABLE V The results of metallographic observations, microhardness and hardness measurement of some lump and blooms

No.	Object	Locality	Structure constituents	Grain size	Microhardness, kg/mm²	Vickers hardness, kg/mm²
1	Lump of iron	Przybyslaw, nr. Znin	Ferrite	5	89·5	89·6
2	Bloom	Witow, nr. Pinczow	Ferrite	4	133	95·8
			Pearlite	7*	235	} 274
			Ferrite	8*	160	
			Pearlite	3	267	
3	Bloom of steel (no.1)	Gdańsk	Pearlite		207	} 139
			Ferrite	†		
4	Bloom of iron (no.2)	Gdańsk	Ferrite	3	205	134·3
5	Bloom of iron (no.5)	Tum, nr. Łeczyca	Ferrite	2	192	113

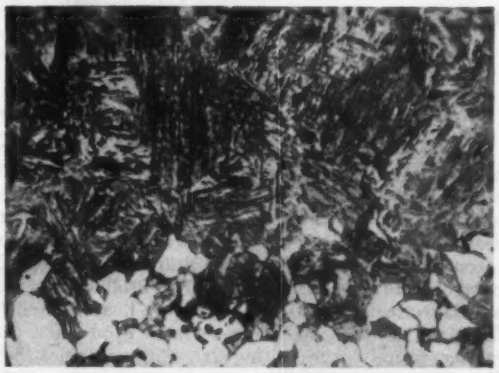
* In the intermediate ferritic–pearlitic part † At grain boundaries.

33 *Macrostructure of lateral cross-section of scythe from Wyciaze, near Krakow (2nd–1st centuries B.C.); dark areas are carburized parts; etched in nital* ×8

found at Kolobrzeg (9th–10th centuries A.D.).[39] It consisted in manufacturing from steel only the working parts of tools, e.g. edges of knives, shears, or swords, while the remaining parts were made of soft iron. The iron and steel portions were joined together by the welding process.

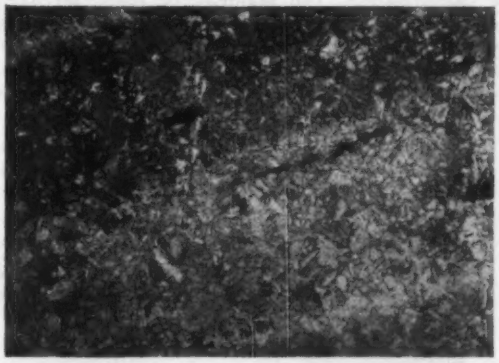
This so-called 'multilayer technique' found a wide application in production of arms and all kinds of tools (Figs.41–45). The steel parts of the objects were usually quite simple; in some cases, to increase the strength, they were serrated (Fig.46). The multilayer technique required a great deal of skill from the medieval iron smelter, as the layers of steel, in some cases, were very thin (Fig.47).[14, 33, 40–44] A medieval spear head (from Lutomiersk, 11th century A.D.) was welded from five to nine layers of iron and steel. Other iron objects, e.g. spurs, stirrups, nails, horseshoes (*see* horseshoe from Piekary, near Krakow, Tables VI–VIII), needles and buckles, were made from soft iron without any hardening processes. The multilayer technique catered for an extensive steel economy. There was a large demand for steel in the 9th–13th centuries A.D. because of social developments and the formation of many new states in middle and eastern Europe.

At the same time some classification methods for the quality of iron were first introduced; apparently they were based on the P content of the metal. The tests were probably carried out either by cold forging, or by heating the metal and observing the increase in the grain size on cooling. Metallographic observations

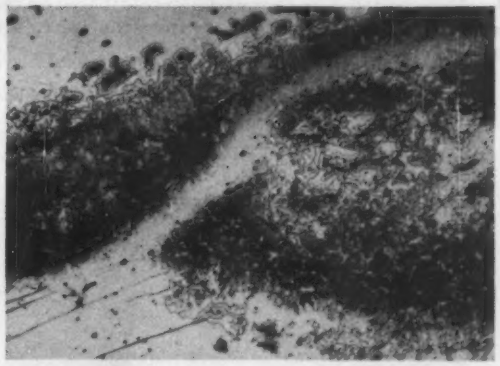


34 *Structure of scythe from Wyciaze; martensite and ferrite; etched in nital* ×500

36 *Macrostructure of lateral cross-section of knife from Biskupin, near Znin (3rd–4th centuries A.D.); dark areas are carburized parts; etched in nital* ×8

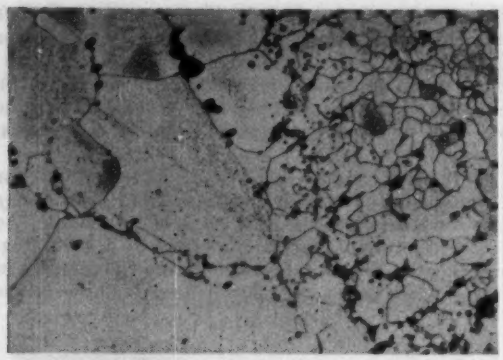


35 *Structure of carburized portion of scissors from Szwajcaria near Suwalki (3rd–4th centuries A.D.); troostite; etched in nital* ×100



37 *Structure of knife from Biskupin; martensite and ferrite; etched in nital* ×500

38 *Macrostructure of lateral cross-section of sword from a tomb at Wachock, near Ilza (3rd–4th centuries A.D.); dark areas are carburized parts; etched in nital* ×3



39 *Structure of sword from Wachock; small grain size ferrite and some pearlite, carburized layer (right); and large grain size ferrite, weakly carburized layer; etched in nital* ×100

indicate that bloomery iron with higher P content has a tendency to grain growth (Fig.48).

On early medieval metallurgy some important investigations were carried out of the ore, slag, and iron objects from Gdańsk where, in 1948–55, archaeologists discovered 17 distinct settlement levels, from about 980 to 1308 A.D., when Gdańsk was burned by the Teutonic Knights. The smelters from Gdańsk produced iron and steel from the local bog ores having high P contents (Figs.49 and 50). The P content found in steel is smaller than that in iron, which supports the theory of the bloomery process proposed by Schürmann.[45] According to this theory, strong carburization conditions repress the transfer of phosphorus from the ore to the metal and the greater part of the phosphorus goes into the slag. The change of P_2O_5 content in the slag is small, for the weight ratio iron/slag in the bloomery is low. This phenomenon is clearly presented in the correlation table, based on the examination of 150 iron objects from the 1st to 4th centuries A.D. (Table IX).

41 *Macrostructure of lateral cross-section of knife from Biskupin, near Znin (9th century); the steel layer between the iron layers appears as a dark layer; etched in nital* ×8

Among 44 cutting tools from Gdańsk that were examined, nine were hardened by cementation, 29 welded from iron and steel, and the remainder were forged either from iron or steel; 39 tools were heat-treated. Similarly, among 33 tools and weapons from Lutomiersk, near Łask (swords, knives, spearheads), seven objects were carburized and 23 produced by the multilayer technique; 18 objects were heat-treated.[40] The same technological processes were applied by the smelters from Łeczyca in the 12th–13th centuries.[42, 46] (This large ironmaking centre was mentioned in 1136 in the edict of Pope Innocent II.) Iron was produced from the bog ores (high P content), and hardened often by carburization. The majority of tools, however, from Tum, near Łeczyca were found to be produced by the multilayer technique. Among 23 examined tools only two were carburized, and 14 were welded from iron and steel; 13 objects were heat-treated. The

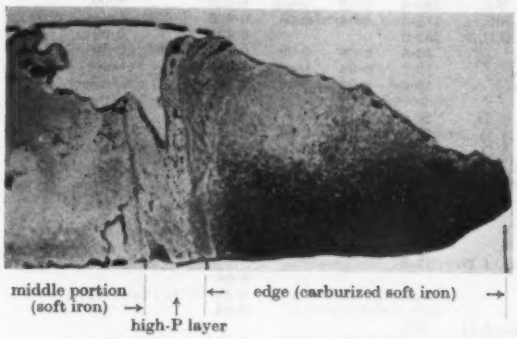
40 *Macrostructure of lateral cross-section of knife from Gdańsk (site 5) 13th century; dark areas are carburized portions; etched in nital* ×6·5

42 *Macrostructure of lateral cross-section of knife (no.7) from Gdańsk site (2), (13th century); steel portion seen as dark area; etched in nital* ×5

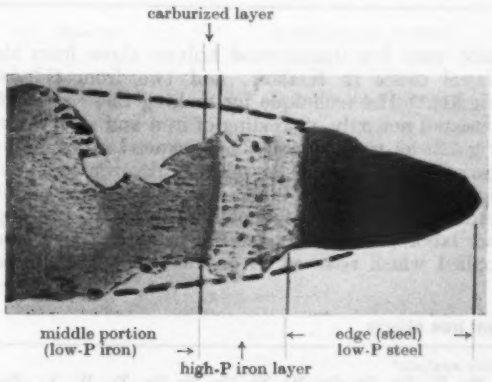
iron axe (no.3) is an example of the multilayer technique; it has a V-shaped steel edge put on its blade (Fig.4, and no.17 Tables VI–VIII).

A particularly interesting detail of the technique used in this area, was the introduction of a thin layer of iron, with high P content, which was placed between the layers of low-phosphorus iron and steel. It is not known why this technique was used; perhaps they used it to facilitate the welding process of low-phosphorus iron and steel. Among 12 spear heads from Lutomiersk,[40] eight heads had the high-phosphorus layers inserted in them (Fig.44). This technique was used by smiths in Tum, near Łeczyca.[43, 46]

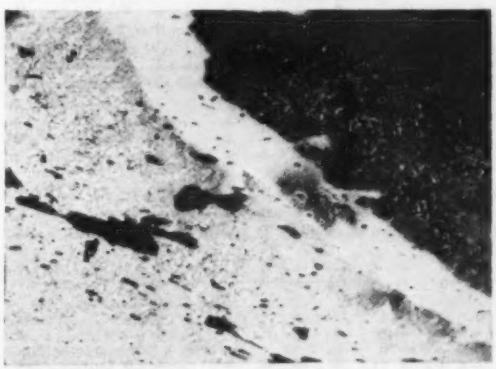
Another interesting method of the multilayer technique is observed, when along one seam, steel and iron, and along another seam, iron and another type of iron (e.g. containing a different amount of P), are joined together in one object. An example of this is a spear head (no.7) from Lutomiersk (Fig.44, Tables VI–VIII).[40] To carry out the welding of the whole object



43 *Macrostructure of lateral cross-section of spearhead (no.4) from Lutomiersk, near Lask (11th century); dark area is carburized portion, etched in nital; reduced in reproduction* ×8

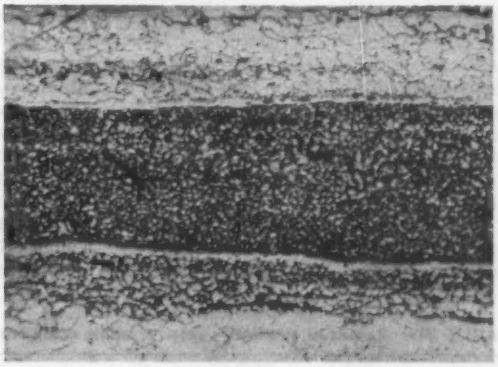


44 *Macrostructure of lateral cross-section of spearhead (no.7) from Lutomiersk, near Lask (11th century); dark areas and steel edge are carburized portion; etched in nital; reduced in reproduction* ×8

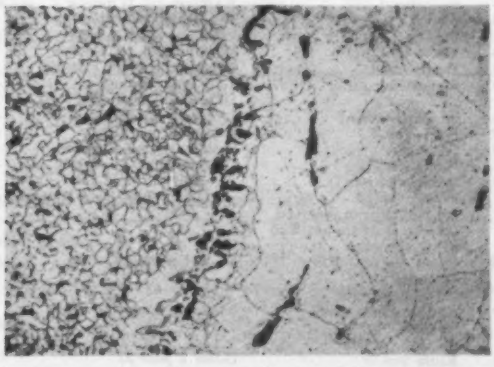


45 *Structure of iron in knife (no.7) from Gdańsk (site 4), (13th century); in steel portion* (top right) *martensite, in iron portion* (bottom left) *ferrite; etched in nital* ×100

46 *Steel layer (dark) of knife (no.11) from Gdańsk (site 1) 11th century); after polishing the knife on the length (20 mm) it was etched several times, alternately, with concentrated and diluted* HNO_3



47 *Steel layer in the knife (no.4) from Wawel (Krakow) (11th–12th centuries); in steel portion* (middle), *small grain size ferrite and pearlite, in iron portions, ferrite; etched in nital* ×100



48 *Structure of multilayer spearhead (no.10) from Lutomiersk (11th century); in soft steel portion* (left) *small grain size ferrite and traces of pearlite, in iron portion (having higher P content), coarse grains of ferrite, etched in nital* ×100

TABLE VI Results of chemical analysis of ancient iron objects

No.	Object	Locality	Date	Weight of object, g	Content, % Si	Mn	P	S	Ni	Cu
1	Flat axe	Gorszewice, nr. Szamotuly	8th–6th cent. B.C.	62·0	0·056		0·003		0·00	
2	Bracelet	Manieczki, nr. Srem	6th–4th cent. B.C.	126·0	0·131	0·00	0·031		0·00	
3	Spearhead	Skrajna, nr. Kalisz	6th–4th cent. B.C.	89·9	0·075	0·00	0·006		0·00	
4	Sickle (no.1), portion	Biskupin, nr. Znin	6th–4th cent. B.C.	11·0	0·00	0·00	0·22		0·00	
5	Spearhead	Karncza, nr. Wroclaw	4th–2nd cent. B.C.	160·6	0·18	trace	0·420		0·00	
6	Sword	Iwanowice, nr. Miechow	2nd–1st cent. B.C.	472·0	0·04	0·00	0·026	0·008	trace	0·00
7	Scythe	Wyciaze, nr. Krakow	2nd–1st cent. B.C.	262·0			0·43		0·00	
8	Knife (no.3)	Wymyslowo, nr. Gostyn	1st cent. B.C.	30·5	0·06	0·00	0·202	0·004	0·00	0·00
9	Pestle (no.1)	Domaradzice, nr. Rawicz	1st cent. A.D.	10·7	0·00	trace	0·056		trace	
10	Spearhead (no.3)	Jadowniki Mokre, nr. Dabrowa Tarnowska	2nd cent. A.D.	75·0	0·00	0·17	0·03			
11	Sickle (portion)	Igolomia, nr. Proszowice	2nd–4th cent. A.D.	20·0			0·46		trace	
12	Knife (no.1)	Biskupin, nr. Znin	3rd–4th cent. A.D.	31·0	0·00	0·00	0·48			
13	Scissors	Szwajcaria, nr. Suwalki	3rd–4th cent. A.D.	211·5	0·06	0·00	0·07		trace	
14	Knife (no.3)	Czerchow, nr. Łeczyca	9th–10th cent. A.D.	10·0	0·17	trace	0·20		0·00	
15	Spearhead (no.7)	Lutomiersk, nr. Łask	9th cent. A.D.	367·3						
	(a) steel edge						0·05			
	(b) high-P iron inserted						0·35			
	(c) iron (middle portion)						0·05			
	(d) iron socket						0·04			
16	Knife (no.6)	Wawel (Krakow)	11th–12th cent. A.D.	13·5						
	(a) edge						0·04			
	(b) pattern portion						0·39			
	(c) back portion						0·32			
17	Axe (no.3), portion	Tum, nr. Łeczyca	12th–13th cent. A.D.	8·7						
	(a) edge				0·01	0·00	0·04			
	(b) iron portion				0·05	0·00	0·22			
18	Knife (no.7)	Gdańsk (site 2)	13th cent. A.D.	34·0						
	(a) edge						0·06		trace	
	(b) back portion				0·00	0·03	0·20		trace	
19	Horseshoe (no.2)	Piekary, nr. Krakow	13th cent. A.D.	96·0	0·12	0·00	0·13	0·008	0·00	

in the same time (i.e. at the same temperature), the iron surface of the portion that is to be in contact with another iron part was carburized, and thus the same conditions were obtained for both seams (steel–iron and carburized iron–iron). This technique was known to smiths in Tum, near Łeczyca (12th–13th centuries).

The highest achievement of the early medieval smiths was with 'damascened' knives. Among 82 knives from the 10th to 13th centuries examined, there were five damascened knives: three from the Wawel castle in Krakow, and two from Gdańsk (Fig.51).[14] The technique for making these products consisted not only of welding of iron and steel layers (Fig.52), as was supposed by France-Lanord,[47] but also of including some low-phosphorus iron and some high-phosphorus iron layers. After a special plastic deformation treatment, including twisting, bending, and laborious forging, careful heat-treatment was applied which resulted in peculiar laminated metal

TABLE VII Results of qualitative spectrographic analysis of ancient iron objects

No.	Object	Locality	Qualitative analysis* Al	As	Ba	Bi	Ca	Co	Cu	Mg	Ni	Pb	Sb	Sn	Ti	W	V	Zn
1	Flat axe	Gorszewice, nr. Szamotuly	+	+		+	+		0	+	+	0		0	0			+
2	Bracelet	Manieczki, nr. Srem	+	0		0	+		0	+	+	+		+				0
3	Spear head	Skrajna, nr. Kalisz	+	0	+	+	+		0	+	+	+		+	0			+
4	Sickle (no.1), portion	Biskupin, nr. Znin	+	+	+	+	+		+	+	+	+		+	0			+
5	Spearhead	Karczna, nr. Wroclaw	+	+	+	+	+			+	+	+		+	0			+
6	Sword	Iwanowice, nr. Miechow	+	+	0	+	0		0	+	+	+		+	0			0
7	Scythe	Wyciaze, nr. Krakow	+	0	+	+	+		+	+		+		+	+			+
8	Knife (no.3)	Wymyslowo, nr. Gostyn	+	+		0	+		+	+	0	+		+	0			0
9	Pestle (no.1)	Domaradzice, nr. Rawicz	+	+	0	0	+	0	+	+	+	0		+				+
10	Spearhead (no.3)	Jadowniki Mokre, nr. Dabrowa Tarnowska	+	+	0		+		+	+	+	+		+	+			0
11	Sickle (portion)	Igolomia, nr. Proszowice	+	0	0	0	+		+	+	0	0		+	?			+
12	Knife (no.1)	Biskupin, nr. Znin	+	+	+	+	+		+	+	+	+		0	0			+
13	Scissors	Szwajcaria, nr. Suwalki	+	0	0	0	+	0(?)	+	+	+	+		+	0(?)			0
14	Knife (no.3)	Czerchow, nr. Łeczyca	+	+	+	0	+		+	+	+	+		+				+
15	Spearhead (no.7)	Lutomiersk, nr. Łask																
	(a) steel edge		+	0			+		+	+	+	0		+				+
	(b) high-P iron inserted																	
	(c) iron (middle portion)		+	0		+	+		+	+	+	+		+	0			+
	(d) iron socket		+	0		0	+		+	+	+	+		+	0			+
16	Knife (no.6)	Wawel (Krakow)																
	(a) edge		+	+	0	0	+	0	+	+	+			+	0(?)	?		0
	(b) back portion		+	+	0	0	+	+	+	+	+			+	0(?)	?		?
17	Axe (no.3), portion	Tum, nr. Łeczyca																
	(a) edge		0	0	0	0	+		+	+	+	+		+				+
	(b) iron portion		+	+	+	0	+		+	+	0	0		+				+
18	Knife (no.7)	Gdańsk (site 2)																
	(a) edge		+	0	+	+	+		+	+	+	+		+	0			+
	(b) back portion		+	0	0	+	+		+	+	+	+		+	0			+
19	Horseshoe (no.2)	Piekary, nr. Krakow	+	+	0		+			+	+			+	+			+

* Also Fe, Si, Mn, P, and S, which are always present in the bloomery iron. In objects 3–8 and 13 there were probable traces of Ag.

TABLE VIII Results of metallographic observations, microhardness, and hardness measurements of iron objects

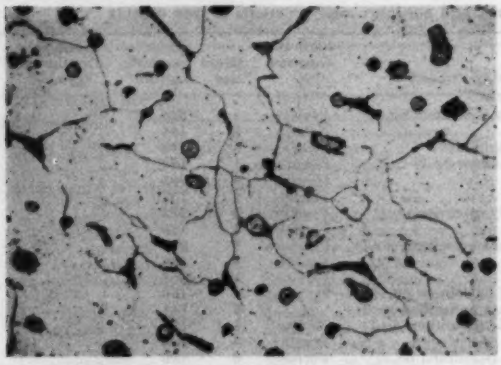
No.	Object	Locality	Source of specimen*	Structure constituents	Grain size	Micro-hardness, kg/mm²	Vickers hardness, kg/mm²
1	Flat axe	Gorszowice, nr. Szamotuły	(1) Edge (specimen no.1)	Pearlite	5	258	128·4–107·7
				Ferrite	8	184	
			(2) Back of axe (specimen no.2)	Pearlite	5	243	160–131·9
				Ferrite	†	162	
2	Bracelet	Manieczki, nr. Srem		Pearlite	4	308	230–112·5
				Ferrite	6	137	
3	Spearhead	Skrajna, nr. Kalisz	(1) Leaf (specimen no.1)	Pearlite	3	222	139·2
				Ferrite	5	120	
			(2) Socket (specimen no.2)	Pearlite	6	288	
				Ferrite	6	126	
4	Sickle (no.1), portion	Biskupin, nr. Znin		Ferrite	5	192	187
5	Spearhead	Karncza, nr. Wrocław	(1) Leaf (specimen no.1)	Ferrite	5	160	147·2
			(2) Socket (specimen no.2)	—	5	144	
6	Sword	Iwanowice, nr. Miechow	(1) Blade (specimen no.1)	Ferrite	4	177	102·9
				Pearlite	5	258	
			(2) Hilt (specimen no.2)	Ferrite	6	196	125·4
				Pearlite	6	303	
7	Scythe	Wyciaze, nr. Krakow		Martensite		733	
				Ferrite	3	210	165
8	Knife (no.3)	Wymyslowo, nr. Gostyn		Ferrite	3		97·1
				Ferrite	7	158	
9	Pestle (no.1)	Demaradnice, nr. Rawicz		Ferrite	6	175	148·8
				Pearlite	7	251	
10	Spearhead (no.3)	Jadowniki Mokre, nr. Dabrowa Tarnowskä	(1) Leaf (specimen no.1)	Ferrite	3	280	164
				Pearlite	3	139	
				Cementite	†		
			(2) Socket (specimen no.2)	Pearlite	4	303	122
				Ferrite	4	139	
11	Sickle (portion)	Igolomia, nr. Proszowice		Martensite		414	481
				Ferrite	2	230	185
12	Knife (no.1)	Biskupin, nr. Znin		Martensite		514	236
				Ferrite	4	239	
				Troostite		460	228
				Ferrite	2	228	
13	Scissors	Szwajcaria, nr. Suwalki	(1) Edge (specimen no.1)	Troostite		418	308–193
				Ferrite	6	156	
			(2) Handle of scissors (specimen no.2)	Pearlite	8		110·3
				Ferrite	8	149	
14	Knife (no.3)	Czerchow, nr. Leczyca		Martensite		514	488
				Ferrite	7	216	163
				Ferrite	4	223	
15	Spearhead (no.6)	Lutomiersk, nr. Łask	(1) Leaf (specimen no.1)				
	(a) steel edge			(a) edge		Martensite	537	508
	(b) high-P iron inserted			(b) iron inserted		Ferrite	3	237	248
	(c) iron (middle portion)			(c) iron (middle portion carburized)		Pearlite	7	186	
						Ferrite	7	170	
	(d) iron socket		(2) Socket			Ferrite	4	166	
16	Knife (no.6)	Wawel (Krakow)	(1) Edge			Martensite		647	635
	(a) edge					Troostite	†	454	
	(b) pattern portion		(2) The damascene portion of knife			Ferrite	7	216	
						Troostite	6	329	
						Ferrite	7	274	
						Troostite		429	
						Ferrite	7		
						Troostite		435	
						Ferrite	7	257	
	(c) back portion		(3) Back portion of knife			Ferrite	6	199	142
17	Axe (no.3), portion	Tum, nr. Łeczyca	(1) Edge			Martensite		525	406
	(a) edge								
	(b) iron portion		(2) The iron portion			Sorbite	7	358	
						Ferrite	6	168	165
						Ferrite	3	147	151·4
18	Knife (no.7)	Gdańsk (site 2)	(1) Edge			Martensite		567	
	(a) edge					Troostite		536	348
	(b) back portion		(2) Back portion of knife			Ferrite	4	219	155
19	Horseshoe (no.2)	Piekary, nr. Krakow				Ferrite	4	183	147

* For specimens cut from various parts or for the 'multilayer' objects. † At grain boundaries.

TABLE IX Correlation table of relationship between carburization and P content in bloomery iron*

Metal, degree of carburization, %C	Number of iron objects with P content in range, %																Total
	0·10		0·20		0·30		0·40		0·50		0·60		0·70		0·80		
Very hard steel, 0·8–1·2	2	1															3
Hard steel, 0·5–0·8	9	5		1													15
Mild steel, 0·3–0·5	14	1	2														17
Soft steel, trace–0·3	28	19	9	6	1	1	2										66
Iron, ferritic structure	6	9	11	5	4	1	2	1	1	3	2	1	1	1		1	49
Total	59	35	22	12	5	2	4	1	1	3	2	1	1	1		1	150

* Based on investigation of materials from 1st to 4th century A.D.

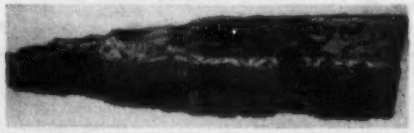


49 *Structure of iron bloom (no.2) from Gdańsk (13th–14th centuries, containing 1·06%S; ferrite and iron sulphide inclusions; etched in nital* ×100

50 *Structure of a bloom of steel (no.2) from Gdańsk (13th century); coarse grain size pearlite, ferrite at grain boundaries, and some slag inclusions; etched in nital* ×100

structures producing characteristic damascene patterns on etching with dilute acids: acicular troostite or sorbitic pearlite (*see* Fig.53).[48] The production of damascened objects with a band of steel, soft iron (i.e. with low P content), and brittle iron, (i.e. with high P content), was described exactly by Perret in the 18th century.[49]

In the 13th–14th centuries appeared the tendency towards simplification of toolmaking technology, particularly as regards the production of knives. The new method consisted of welding a straight steel rod for the edge of the knife, with an iron rod for the back of the knife. This technique first appears in the area mentioned at the end of the 10th century and in the 13th century becomes a very common method of manufacturing knives. Of the 13 examined knives from the 10th to 12th centuries among the iron objects from



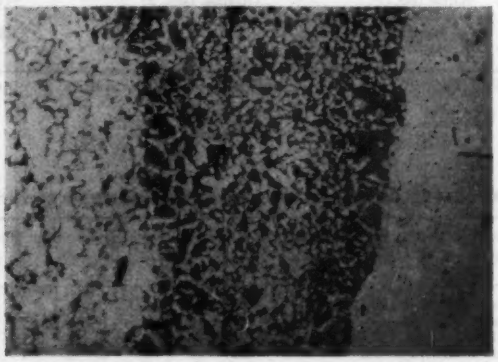
51 *Piece of damascened knife (no.3) found at Wawel (Krakow) (11th–13th centuries); after polishing it was etched several times, alternately with concentrated and diluted* HNO_3

52 *Macrostructure of the lateral cross-section of the damascened knife (no.3) from Wawel; dark areas are steel portions; etched in nital* ×8

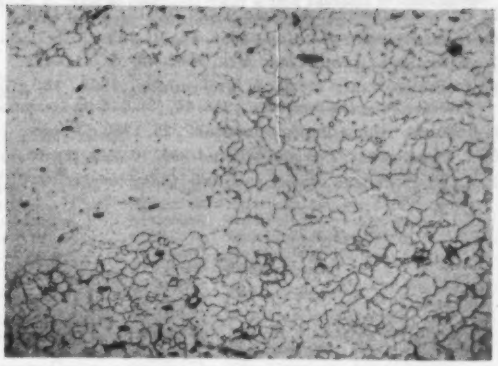
Gdańsk, only one exhibits this technique, but among 24 examined knives from the 13th to 14th centuries, 12 knives of this sort exist (knife no.7, Fig.42 and Tables VI–VIII is an example).

In the Middle Ages, in the territory between the Oder and the Vistula, appeared the first objects from refined iron and iron castings. The sword from Gdańsk (Fig.54), probably imported from Western Europe, was made from refined iron. Its technology was rather primitive, no hardening processes being applied. The hilt of the sword was cast from pig iron containing 3·15%C, 2·09%Si, 0·45%Mn, 1·13%P, and 0·136%S (Fig.55).[50]

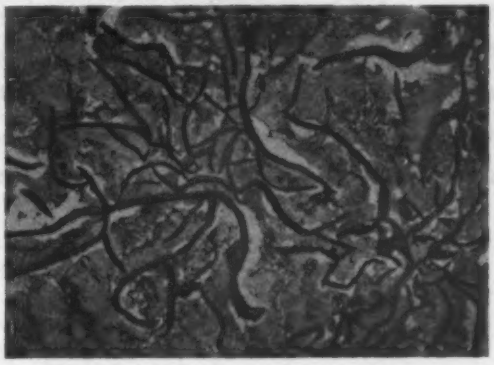
So far no investigations have been carried out of the objects from the 15th century and later. Among several objects examined is a 'bear' from the foundry at Wegierska Gorka, near Zywiec (middle 14th century).[51] The 'bear' occurred from insufficient carburization of metal during the reduction of the ore.



53 *Structures of the damascened pattern of the knife (no.3) from Wawel; ferrite in iron layers, sorbite and ferrite in steel layers; etched in nital* ×100



54 *Structure of sword hilt from Gdańsk (14th–15th centuries); ferrite and small slag inclusions; etched in nital* ×100



55 *Structure of sword hilt from Gdańsk; graphite, pearlite, ferrite, and phosphorus eutectic, etched in nital* ×100

Soft iron, reduced by the bloomery process, collected at the bottom of the furnace, the temperature of the furnace not being high enough to melt it. Thus the run of the blast-furnace had to be stopped. The work described above has not been completed and requires further investigation. The results obtained encourage the continuation of this type of work in Poland, as well as in other countries.

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Beneficiation of ferruginous sandstones of the Northampton sand ironstone formation

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SYNOPSIS

Extensive areas of highly siliceous ironstone exist to the west of the Northamptonshire orefield. Laboratory investigations indicate that a high proportion of the silica can be removed by ore dressing to give a concentrate with an analysis at least equivalent to and perhaps rather better than the ironstone at present mined. Adequate concentration was, however, only achieved when the iron content of the raw material exceeded about 20%. Methods used include (a) *classification by screening and* (b) *magnetic separation after low-temperature reduction roasting, the latter method giving somewhat higher iron analyses and recoveries in the concentrates. No attempt has been made to make any economic appraisal, because of the small-scale nature of the tests carried out.* 1959

INTRODUCTION

THE POSSIBILITY OF concentrating the low-grade Jurassic ironstones of this country has been raised on a number of occasions and the need to find an economic process for removing some of the slag-forming constituents from the ore before charging to the blast-furnace has often been stressed.[1,2]

A certain amount of work on the problem has been carried out on the limy Frodingham[3] ores as well as on the siliceous Northamptonshire ironstones.[4] In general, it can be said that in the case of the limy ironstones, a certain proportion of the lime present can be removed, but that the iron/silica+alumina ratio shows little improvement; the siliceous ironstones still present an insoluble problem due to the intimate association of iron, silica, and alumina, particularly when present as the mineral chamosite. It should also be mentioned that Reeve[5] developed a chemical process for concentrating low-grade iron ores. This process depended on the extraction of the iron with hydrogen chloride gas or aqueous hydrochloric acid as ferric chloride, which was hydrolyzed with steam to give pure ferric oxide and hydrogen chloride. The latter could then be re-used in the process. The failure, however, to find an economic process for beneficiating home ores and the advances made in blast-furnace operation with sintered low-grade ores have both combined to discourage further work on this problem.

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Hitherto, all research has been carried out on ironstones which are at present being exploited. In the Northamptonshire ironstone field, however, there are certain ferruginous sandstones which are at present too low-grade to be worked economically or even to be included in any of the normal classes of reserves. These sandstones occur on the margins of the field: for instance, to the west and south-west of Northampton, where considerable tonnages are known to exist. The iron content is not likely to be much higher than 20%, except locally, but much of the silica is present as grains of quartz whose size is of the order 0·15–0·20 mm. Hence the possibility of removing at least a part of the silica by conventional ore dressing methods clearly becomes a more practical proposition in terms of concentrating the ironstone, at least up to the grade of the ore at present mined. It would, however, be

TABLE I List of localities from which samples of Northampton sand ironstone were collected

Locality	Ordnance Survey map reference	Remarks
South of R. Welland		
Thorpe Mandeville	SP516447	Small pit
Warden Hill	SP514503	N side of hill. Somewhat overgrown
Eydon	SP539507	Quarry. 400 yds NNW of Eydon
Maidford	SP612526	Small pit. 150 yds E of church
Stowe Lodge	SP630565	Small pit near Lodge gate
Church Stowe	SP644575	Quarry at Manor Farm
Upper Stowe	SP654565	Road cutting on A5
Duston	SP728609	Disused quarry
Harlestone	SP708638 SP712637	Two quarries
E. Haddon	SP668672	Small pit on top of hill
Botany Farm	SP656711	300 yds W of farm. SW of Guilsborough
Highgate House	SP709712	Old 'gravel' pit SW of house
Great Creaton	SP700721	Quarry overgrown
Hollowell	SP688721	Road cutting in village
Maidwell	SP738768	Overgrown pit WSW of village
Dingley	SP773864	Road cutting
North of R. Welland		
Ling's Hill	SK818283	Small exposure on escarpment
Waltham-on-the-Wolds	SK800240	No exposure
Preston	SK872030	Road cutting N of village
Ridlington	SK828025	Small pit west of village
Uppingham	SP846983	Old pits at Kings Hill
Stoke Dry	SP863974	Overgrown pit NE of village
Uppingham	SP866988	Adderley-glebe quarries, now overgrown
Neville Holt	SP823988	Small exposure in field

optimistic to expect to make a concentrate containing more than 50%Fe since the iron oxides and clay are extremely intimately associated.

The small-scale nature of the tests described preclude any serious economic appraisal of the problem and no attempt has therefore been made. It can be said, however, that since the reserves quoted below include only outcrop or shallow stone, mining costs would be low. Equally crushing and grinding should also be relatively cheap since the material is in general very soft. Larger scale pilot plant tests would be necessary to provide a reasonable estimate of concentration costs. With a wet process, dewatering would be an important item.

OCCURRENCE

The Northampton sand ironstone field extends from Lincoln in the north to the neighbourhood of Towcester in the south. The eastern margin is less clearly defined since it is buried under deep cover, while to the west the ironstone either outcrops along a well-defined escarpment or passes into highly siliceous ferruginous sandstones.

Three areas on the western margins of the ore field contain significant tonnages of this material. Very approximate estimates of reserves, which are in addition to those usually quoted, are as follows:[6]

(i) *Northamptonshire* (south of the River Welland)
West and south-west of Northampton in the neighbourhood of Duston, Harlestone, Chapel Brampton, Stowe-nine-Churches, Patishall, and Maidford.

About 3750 acres of outcrop or shallow stone; assuming an 8-ft bed, say, *75 million tons.*

(ii) *Rutland and South Lincolnshire* (north of the River Welland)

(*a*) Uppingham–Ridlington area.
About 2000 acres of outcrop or shallow stone; say, *40 million tons.*

(*b*) Waltham-on-the-Wolds–Stonesby area.
About 3000 acres of stone with less than 50 ft of overburden; say, *60 million tons.*

The total reserves quoted, all opencast, may only be considered as potential iron ore if an economic process can be devised for upgrading them.

DESCRIPTION OF THE IRONSTONE

From both a lithological and a geographical point of view, the River Welland provides a convenient division between the types of ironstone examined.

South of the River Welland, highly siliceous Northampton Sands occur from about 10 miles north of Northampton to Thorpe Mandeville about 17 miles to the south-west. This area is the type locality from which the Northampton sand ironstone formation takes its name.[7] Locally the formation attains its maximum thickness of nearly 70 ft. In the central part of the field, e.g. around Corby, a five-fold sub-division of the ironstone is possible on a petrological basis. Traced towards the western margins of the field, including the area under discussion, the ironstone becomes non-oolitic and much of it passes laterally into highly siliceous ferruginous sandstones. Thus the type area is by no means typical of the ironstone field as a whole, since these beds are unrepresented over most of the field, where the ironstone has an average thickness of no more than 15–25 ft.

North of the River Welland, in Rutland and South Lincolnshire, the western margin of the Northampton sand formation continues to be represented by siliceous ironstone in a series of outliers and spurs close to and

TABLE II Size distribution and chemical analyses below 200 mesh

Nominal size fraction (micrometres)	Wt-%	Cumulative wt-%		Chemical analysis, % Fe	SiO_2	Al_2O_3	Distribution, % Fe	SiO_2	Al_2O_3
76–37·5	21·8	−76	100·0	32·14	20·80	9·48	22·8	22·5	13·9
37·5–26·5	6·0	−37·5	78·2	32·74	20·20	11·96	6·4	6·1	5·0
26·5–18·8	8·9	−26·5	72·2	34·74	19·06	11·20	10·2	8·5	6·9
18·8–13·2	14·5	−18·8	63·3	31·95	18·08	15·31	15·2	13·1	15·3
13·2–9·2	34·2	−13·2	48·8	29·55	18·48	17·19	33·4	31·4	40·4
<9·2	14·6	−9·2	14·6	25·26	25·50	18·12	12·0	18·4	18·5
	100·0			(30·63)*	(20·13)*	(14·53)*	100·0	100·0	100·0

* Calculated mean analysis of sample

along the eroded escarpment. These areas include the Waltham-on-the-Wolds–Stonesby area, south-west of Grantham, and the outliers capped by the Northampton Sand between Oakham and the River Welland.

In the Northampton area, the material collected and examined consisted essentially of ferruginous sandstones, that is to say, abundant quartz grains loosely cemented by limonite and clay. North of the Welland, the marginal beds, while still siliceous and quartz-bearing, resemble more closely the ironstone proper. Oolitic structures are common and the iron content is higher.

Since most of the areas investigated were away from the ore field proper and in essentially agricultural country, good exposures were not to be expected. However, a fair number of samples were collected and are considered to be fairly representative. These localities are listed in Table I and shown on Fig.1.

Microscopic examination of samples collected near Northampton showed that the stone consisted essentially of angular and sub-angular grains of quartz set in a matrix of dense fine-grained limonite. The grain size of the quartz was variable but greater than 200 mesh (0·074 mm). Thus at Duston, much of the quartz was in the 100–200 mesh range (0·152–0·074 mm) while another sample from Stowe Lodge was somewhat coarser (60–100 mesh or 0·50–0·152 mm). The limonitic matrix, however, was similar in all the samples examined. The presence of alumina in the chemical analysis is attributed to clay. X-ray examination of the matrix after removal of the iron in cold dilute acid indicated the presence of kaolinite ($Al_2O_3.2SiO_2.2H_2O$). This clay mineral is widespread in the ore field since it is a decomposition product of chamosite. Its presence in the sandstones would therefore be expected.

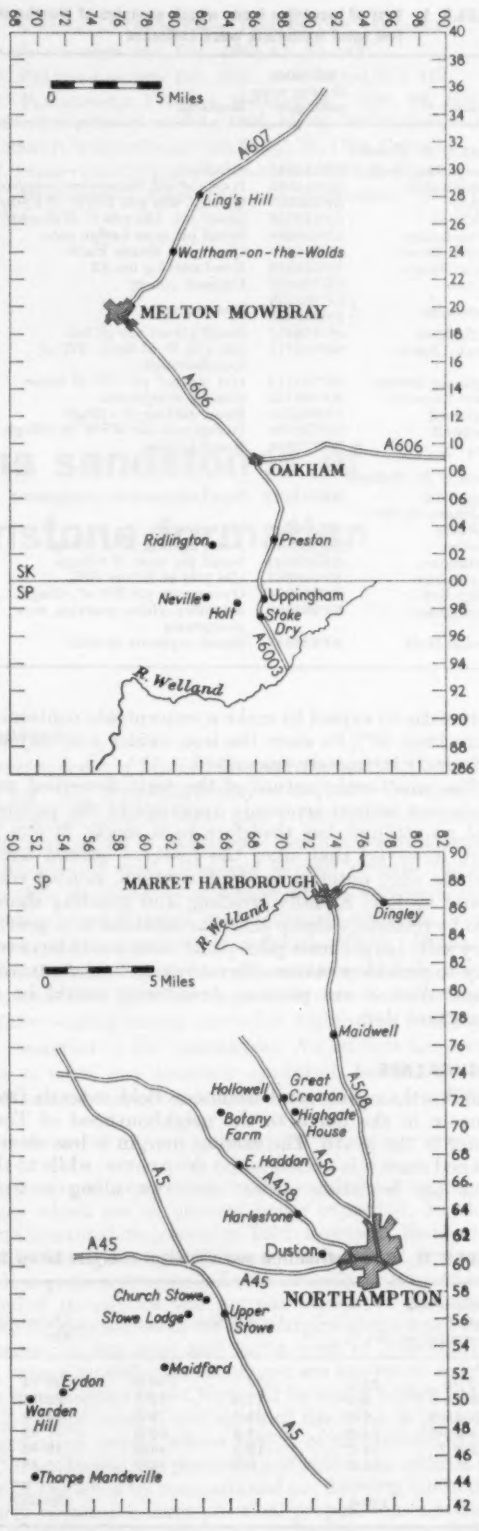
In Rutland and south Lincolnshire, the siliceous Northampton sands to the west of the ore-field occur as quartz-bearing oolitic ironstones. Under the microscope, the ooliths, usually flattened, have a maximum size of about 0·3 mm; they are usually light brown in colour and slightly pleochroic. While the samples appear to be highly oxidized, the optical properties of the ooliths indicate that some chamosite is still probably present. Angular quartz grains are common, sometimes abundant, and up to 0·30 mm in size. One or two thin sections contain calcite as fossil fragments; this, however, is not usual. The matrix consists of dense limonitic material, which is sometimes crystalline.

CHEMICAL COMPOSITION

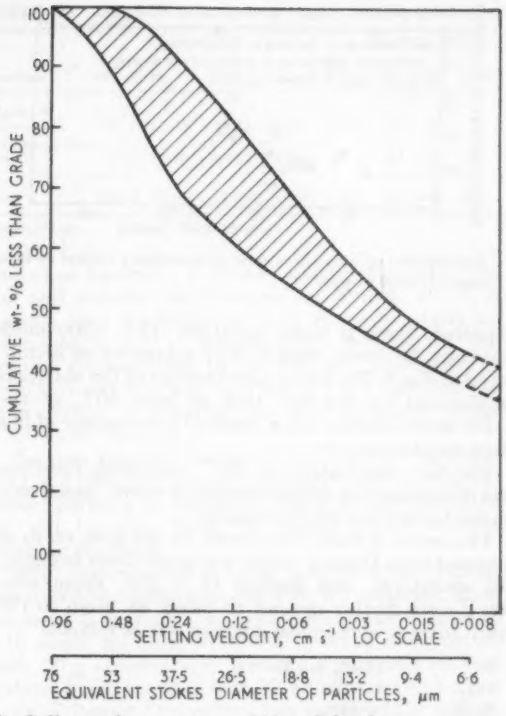
The change in mineralogical composition north and south of the River Welland is also reflected in rather different chemical compositions. In the Northampton area, the beds are true sandstones, with wide variations in chemical analysis:

Fe	30–8%
CaO	1–2%
SiO_2	32–75%
Al_2O_3	4–10%

In general, the iron is not more than 20% and silica usually lies between 50 and 60%. The true distribution of chemical analysis would require extensive pitting and trenching to ensure reasonable sampling. Lime, especially in the Northampton area, is always low.



1 *Locality of area*



2 *Sedimentation curves on −200 mesh fractions*

The larger part of the silica which occurs as quartz is in the +200 mesh size range, while the iron and alumina tend to be concentrated below 200 mesh. As would be expected, the relative proportions of iron, alumina, and silica vary considerably below 200 mesh according to the size fraction considered. Table II shows the results obtained from analysing five fractions in the sub-sieve range. These fractions were isolated using a standard decantation procedure. There is a marked concentration of alumina in the finest fractions, especially below 13·2 micrometres. This is not unexpected since the alumina occurs as a clay mineral.

Further north in Rutland and South Lincolnshire, the siliceous beds are richer in iron and lower in silica, and may approach ore grade. The iron content is often around 30% with the silica between 20 and 30%.

POSSIBILITIES OF CONCENTRATION

Over he Northamptonshire ore field as a whole, the mineralogical constitution of the ores does not lend itself to any of the conventional methods of concentration. Primarily this is because most of the silica and alumina is combined with iron in the mineral chamosite. Hence rejection of these slag constituents can only be achieved with substantial iron losses. Where the ore is oxidized, chamosite breaks down to an intimate mixture of limonite and clay which requires extremely fine grinding for their liberation. Furthermore, a combination of low mining costs and other favourable factors enables these ores to be smelted profitably without concentration. There has, therefore, been comparatively little incentive to find a solution to the ore-dressing problems common to many ores of this type.

With the introduction of much of the silica as quartz into these ironstones, the possibilities of ore dressing become more hopeful and the removal of some of the silica a more practical proposition. There is also the fact that the iron/silica ratio is so unfavourable in the marginal areas that the ironstones described can never be considered as ore unless some of the silica can be removed in some pre-concentration step.

A technically successful process would potentially increase the ironstone reserves by at least 150 m. tons of readily obtainable stone equivalent to perhaps 30 m. tons of contained iron.

A number of methods of concentration present themselves: including classification, and magnetic separation, after roasting under reducing conditions. Small-scale tests have been carried out and give some idea of the possibilities of each method. Gravity separation was not seriously investigated apart from a single heavy liquid separation on a sample from Duston (*see* Table I for localities). Using bromoform (sp. gr. 2·90) the iron content was increased from 24% to 36·5% and the silica reduced from 69% to 25%. The iron recovery was 75%.

TABLE IV Final results of dry magnetic separation

Fraction	Wt-%	Analysis, % Fe	SiO_2	Al_2O_3	Fe/SiO_2	Distribution, % Fe	SiO_2	Al_2O_3
−200 mesh	33·1	37·6	19·7	11·2	1·91	54	13	58
+200 mesh	66·9	15·8	62·5*	3·95*	...	46	87	42
	100·0	23·0*	48·4	6·33	0·48	100	100	100

* Calculated

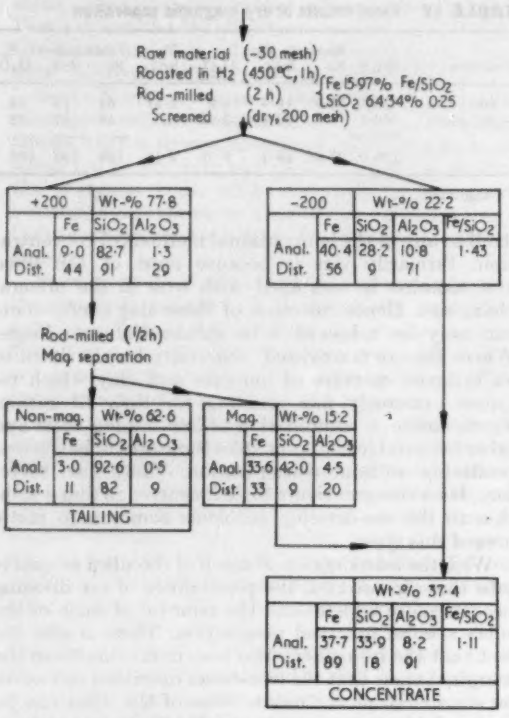
CONCENTRATION TESTS

Classification

The extremely fine-grained nature of the limonitic matrix combined with the somewhat coarser condition of the quartz suggested that concentration might be possible on the basis of size difference. Size analyses

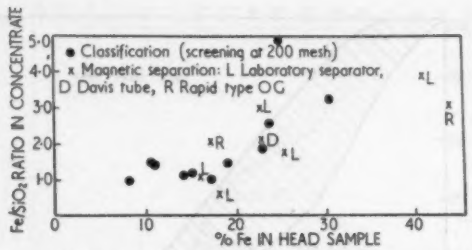
TABLE III Size distribution of +200 mesh fractions

Locality		Warden Hill	Eydon	Maidford	Faulkner's Quarry (Church Stowe)	Road cutting on A5 (Upper Stowe)	Harlestone	East Haddon	Botany Farm	Highgate House	Hollowell
Grade size in mm	Equiv. BSS mesh	Cumulative weight, %									
0·500	+ 30	3·6	12·3	16·2	3·3	8·3	0·1	0·1	6·2	19·2	9·9
0·35	+ 44	5·1	20·8	21·9	10·7	14·4	0·5	1·2	11·0	30·9	18·1
0·252	+ 60	7·1	33·2	26·2	26·4	20·8	1·4	7·1	27·0	47·0	41·2
0·177	+ 85	27·6	58·5	34·0	51·6	33·4	6·0	14·6	42·7	74·1	77·4
0·125	+120	89·5	69·6	90·5	74·3	53·2	55·6	87·4	93·5	90·4	95·2
0·076	+200	100	100	100	100	100	100	100	100	100	100



3 *Combined screening, milling, and magnetic separation of roasted ore, Northampton area*

were carried out on the + and −200 mesh fractions of a number of samples from the Northampton area. The size distribution in the +200 mesh fractions, which was obtained by screening dry on a Syntron electromagnetic vibrator, is given in Table III. As would be



4 *Distribution of iron/silica ratio (concentrate) related to iron assay of head sample*

expected, there is some variation. The −200 mesh fractions, however, show a close similarity as is indicated in Fig.2. The fine-grained nature of the matrix is emphasized by the fact that at least 50% of the −200 mesh fraction has a nominal particle size of less than 15 micrometres.

The size distribution of the −200 mesh fractions was determined by sedimentation in water, based on a method described by Stairmand.[8]

Two series of tests were made. In the first, 60 lb of material from Duston, which is typical of the ferruginous sandstones, was crushed to $-\frac{1}{16}$in. From this, 500 g were further ground to below 85 mesh (0·177 mm). Its partial chemical analysis was as follows:

Fe	24·4% (all Fe^{+++})
SiO_2	48·4%
Al_2O_3	6·33%

The sample was separated into + and −200 mesh fractions by dry screening and the results given in Table IV.

These results show that a large proportion of the silica is rejected in the +200 mesh fraction. It may be inferred from the presence of alumina and the highly oxidized state of the iron that some of the silica is

TABLE V Wet screening tests on sandstones from Northampton area

Locality	Fraction	Wt-%	Chemical analysis, % Fe	SiO_2	Al_2O_3	Fe/SiO_2	Distribution, % Fe	SiO_2	Al_2O_3
Warden Hill	Conc.	41·0	31·82	30·95*	14·41	1·03	76	21	87
	Tail	59·0	7·13*	82·12	1·46*	...	24	79	13
	Head	100·0	17·28	61·14	6·77	0·28	100	100	100
Eydon	Conc.	29·2	28·40	19·42	13·95	1·46	44	10	68
	Tail	70·8	15·08*	75·37	2·73*	...	56	90	32
	Head	100·0	18·96	59·02	6·00	0·32	100	100	100
Maidford	Conc.	36·7	37·86	7·68*	8·28	4·94	56	6	30
	Tail	63·3	17·57 *	64·33	10·95*	...	44	94	70
	Head	100·0	25·02	43·53	9·97	0·58	100	100	100
Faulkner's Quarry (Church Stowe)	Conc.	22·3	15·20	15·70 *	21·76	0·97	41	5	86
	Tail	77·7	6·38*	91·08	1·00*	...	59	95	14
	Head	100·0	8·34	74·27	5·61	0·11	100	100	100
Road cutting (Upper Stowe)	Conc.	56·7	38·30	11·85*	5·36	3·23	71	21	32
	Tail	43·3	20·42*	58·98	15·05*	...	29	79	68
	Head	100·0	30·60	32·26	9·56	0·95	100	100	100
Harlestone	Conc.	33·8	27·00	18·55*	19·71	1·46	85	10	76
	Tail	66·2	2·52*	84·77	3·17*	...	15	90	24
	Head	100·0	10·80	62·40	8·76	0·17	100	100	100
East Haddon	Conc.	37·0	29·40	26·35*	15·13	1·12	75	16	72
	Tail	63·0	5·76*	83·70	3·46	...	25	84	28
	Head	100·0	14·50	62·47	7·78	0·23	100	100	100
Botany Farm	Conc.	27·4	31·82	28·32*	15·51	1·12	58	12	96
	Tail	72·6	8·79*	79·56	0·23*	...	42	88	4
	Head	100·0	15·10	65·52	4·42	0·23	100	100	100
Highgate House	Conc.	31·4	38·84	13·63*	15·96	2·56	54	9	76
	Tail	68·6	18·79*	65·64	2·29*	...	46	91	24
	Head	100·0	23·83	49·31	6·58	0·48	100	100	100
Hollowell	Conc.	20·3	31·22	22·31*	10·77	1·40	57	6	35
	Tail	79·7	6·00*	86·40	4·99*	...	43	94	65
	Head	100·0	11·10	73·40	6·17	0·15	100	100	100

* Calculated value

TABLE VI Magnetic separation of roasted Duston sample

Fraction	Wt-%	Analysis, % Fe	SiO_2	Al_2O_3	Fe/SiO_2	Distribution, % Fe	SiO_2	Al_2O_3
Magnetic (conc.)	32·1	45·15	25·25	1·00	1·78	57	15	5
Non-magnetic (tail)	67·9	16·40	66·12	7·88	...	43	85	95
Head	100·0	25·56*	53·00*	5·67*	0·48	100	100	100

* Calculated

present as kaolinite. It should also be noted that the iron and alumina distributions are similar, and it is possible that an improved iron recovery would be accompanied by a corresponding increase in the alumina recovery due to the intimate association of these two constituents; this would have the effect, to some extent, of lowering the silica rejection in the +200 mesh fraction.

The iron recovery leaves much room for improvement and it would appear to be a question of using the correct grinding technique to ensure the separation of the soft limonite from the quartz grains without breaking the latter.

In the second series of tests, samples from 10 localities in the Northampton area were investigated. Each sample, 4 lb in weight, was crushed in a jaw crusher to −10 mesh, resulting in 80–100% being less than 30 mesh; 50 g samples were put into a porcelain jar mill without balls, together with 50 ml of water and a few drops of Teepol. One or two 1-in lumps of the sample were also added to assist the scrubbing treatment, which consisted of rotating the sample in the mill at 25 rev/min for 1 h. The sample was then wet screened through a 200-mesh screen; the oversize and undersize, after drying, were weighed.

The results of these tests are summarized in Table V.

It is apparent that classification, in this case by screening, of the ground material leads to some concentration of the iron and considerable rejection of the silica. In most cases the alumina tends to follow the iron because of its presence as fine-grained kaolinite. There are wide variations in iron analysis from 8% to 30% and the lower the iron the less favourable is the initial iron/silica ratio. In spite of good rejection of silica and a significant increase in the iron analysis of the concentrate, the iron/silica ratio still remains unfavourable in the concentrate.

Iron recovery is very variable, the best being 85%. It is essential in treating this type of material that the scrubbing operation is efficient to remove the coating of iron oxide from the quartz. The amount of scrubbing necessary depends on the nature of the sandstone and the adherence of the iron oxide to the quartz. While it was not specifically investigated, it would also seem possible to remove some alumina by rejecting a pre-determined size fraction, say below 5 micrometres, without too great an iron loss (*see* Table II).

Roasting and magnetic separation

Magnetic separation is widely used for concentrating magnetite ores, since it is both efficient and relatively inexpensive. Roasting iron ores to convert the iron-bearing constituents to a magnetic oxide (magnetite or γ–Fe_2O_3) has also been investigated. Few such roasting processes, however, have reached the commercial stage, because the heat requirements of the process have not been economically justified or other methods such as flotation have proved less expensive.

A number of experiments were carried out with Northampton sand samples to investigate the possibility of upgrading them by a combination of reduction roasting and subsequent magnetic separation.

Tests on sandstones from the Northampton area

In the first instance, the Duston sample previously used for classification tests was investigated. The sample, −85 mesh (0·177 mm), was heated in a stream of hydrogen for 2 h at 600°C and then in steam for a similar period. Only magnetite was detected in an X-ray powder photograph of the roasted sample.

Subsequent dry magnetic separation was carried out, the magnetic and non-magnetic fractions being retreated. The final results are indicated in Table VI.

While good rejection of silica was obtained and a reasonable iron analysis in the concentrate achieved, the iron recovery is low and the iron/silica ratio in the concentrate is too high to be usable.

Further experiments were carried out on a number of samples. To reduce the ore, a small rotary furnace was constructed. It consisted essentially of a 2-in dia. stainless steel tube which rotated inside an electric furnace. Three lifting vanes were fixed inside the tube to improve the gas/solid contact. Inclination of the tube, speed of rotation, and furnace temperature could all be independently controlled.

Reduction roasting was normally carried out at 350–450°C in a stream of moist hydrogen. Under these conditions, conversion to magnetite of the iron oxide in the raw material was complete.

Three tests were made with a composite sample of sandstones from the Northampton area. Its chemical analysis was as follows:

Fe	18·34%
SiO_2	54·37%
Al_2O_3	6·8%
CaO	1·8%
P	0·27%
S	Trace

TABLE VII Magnetic separation of roasted sample of sandstones from Northampton area

Sample	Fraction	Wt-%	Analysis, % Fe	SiO_2	Al_2O_3	Fe/SiO_2	Distribution, % Fe	SiO_2	Al_2O_3
1	Conc.	56·2	29·10	44·90	8·46	0·58	89	42	73
	Tail	43·8	4·68	80·80	3·91	...	11	58	27
	Head	100·0	18·40*	60·62	6·46	0·32	100	100	100
2	Conc.	33·4	49·21	16·40	7·28	3·00	71	10	33
	Tail	66·6	9·88	70·48	7·44	...	29	90	67
	Head	100·0	23·02*	52·43*	7·39*	0·44	100	100	100
3	Conc.	38·7	43·77	20·94	8·58	2·09	73	16	36
	Tail	61·3	10·09	67·07	9·55	...	27	84	64
	Head	100·0	23·11*	49·22*	9·17*	0·47	100	100	100

* Calculated

TABLE VIII 'Rapid' separation of roasted sandstones from Northampton area

Fraction	Wt-%	Chemical analysis, % Fe	SiO_2	Al_2O_3	Fe/SiO_2	Distribution, % Fe	SiO_2	Al_2O_3
1st magnetic	31·8	42·2	20·8	6·08	2·03	77	11	60·5
2nd magnetic	8·2	22·6	60·6	4·27	0·37	10·5	8·5	10·5
3rd magnetic	0·9	10·1	63·8	} 1·55	...	12·5	1	} 29·0
Tailing	59·1	3·4	79·7		...		79·5	...
	100	17·37*	59·7	3·20	0·29	100	100	100

* Calculated

The material was crushed to −30 mesh (0·500 mm) before roasting. Three magnetic separation tests were carried out on 25-g samples of the roasted ore. The results are summarized in Table VII.

Two samples, 1 and 2, were separated dry on a laboratory separator consisting of a vibrating brass tray (50 cycles/s) 20in long by 3½in wide and inclined at an angle of 20°. An electro-magnet 1in above the tray lifted the magnetic particles from the feed as it passed down the tray.

Sample 1 was separated after roasting without any further treatment. The grade of concentrate is poor and the high recovery is in part due to a middling product consisting of quartz grains coated with magnetite which were recovered in the magnetic fraction.

Sample 2 was lightly rod-milled in a laboratory mill for 2 h before separation. Speed of rotation of the mill was sufficiently slow to prevent cascading of the ore or rods. Subsequent magnetic separation yielded cleaner products with improved iron analysis in the concentrate but lower iron recovery.

Sample 3 after a similar grinding treatment was separated in a Davis Tube Magnetic Separator.

Alumina rejection (except sample 1) is rather better than was achieved by classification.

In a third series another composite sample (−30 mesh) from the Northampton area (18·14%Fe; 61·65%SiO_2; 5·59%Al_2O_3), was roasted in the rotary kiln. The sample, after roasting, was rod-milled for 2 h and divided into two fractions, which were treated as follows:

(i) The roasted material was first screened dry at 200 mesh. The +200 mesh material was then further rod-milled for ½ h and passed through the laboratory magnetic separator. The magnetic fraction from this step was combined with the −200 mesh fraction to give a final concentrate, which is characterized by comparatively low iron (37·7%) with a good recovery (85·5%) but with high silica (33·9%) (*see* Fig.3). Other tests along these lines gave no better results. Thus, in two other cases, the iron and silica analyses were as follows:

%Fe	%SiO_2
38·5 (recovery 88%)	34·4 (recovery 18%)
35·9 (recovery 79%)	41·7 (recovery 19%)

The introduction of the screening stage has tended to introduce more silica into the concentrate while at the same time leaving a very low-grade material for subsequent magnetic separation. There has also been little rejection of alumina, but from the previous screening tests on the unroasted material this would be expected.

(ii) The roasted sample was separated on a 'Rapid', OG type, dry magnetic separator which can be adjusted to give up to six magnetic products and a tailing. In this case only three magnetic products were collected (Table VIII).

Only the first magnetic product was of ore grade. The second product was rod-milled for ½ h and then subjected to a second magnetic separation. Adding the magnetic fraction from this step to the first magnetic product improved the overall iron recovery to 86% but reduced the grade to 41·0%Fe and 23·7%SiO_2 (15% recovery), and the iron/silica ratio to 1·73.

Tests on sandy ironstones from Rutland/South Lincolnshire

The siliceous marginal beds of ironstone in Rutland and South Lincolnshire are, as mentioned previously, quartz-bearing oolitic ironstones and thus more closely related to the ironstone proper. The iron content is higher and the silica lower; in some cases the stone approaches ore grade.

A composite sample, made up from a number of samples, had the following partial chemical analysis:

Fe	36·1%
SiO_2	20·4%
Al_2O_3	9·21%
CaO	3·14%
MgO	1·74%

The composite sample was crushed to ¼in and the −$\frac{1}{32}$in fraction removed before roasting in the rotary kiln, to reduce dust losses.

After roasting, the ore was ground in a laboratory ball mill until it passed through a 22-mesh screen (0·70 mm), the charge being screened every ½h to prevent over-grinding. The ground material was divided into two parts for dry magnetic separation on

TABLE IX Separation on laboratory separator

	Wt-%	Chemical analysis, % Fe	SiO_2	Al_2O_3	Fe/SiO_2	Distribution, % Fe	SiO_2	Al_2O_3
Concentrate	74·5	49·7	12·8	7·85	3·88	90	38	75
Tailing	25·5	16·7	62·1	7·86	...	10	62	25
Head	100·0	41·3*	25·4*	7·80*	1·63	100	100	100

* Calculated

TABLE X Separation on a 'Rapid' OG type separator

	wt-%	Chemical analysis, % Fe	SiO_2	Al_2O_3	Fe/SiO_2	Distribution, % Fe	SiO_2	Al_2O_3
Concentrate	84·9	50·3	16·4	6·52	3·08	96	61	85
Tailing	15·1	10·4	59·5	6·36	...	4	39	15
Head	100·0	44·3*	22·9*	6·49*	1·97	100	100	100

* Calculated

TABLE XI General trend of results achieved

Head sample %Fe	Fe/SiO_2	Method of concentration	Concentrates %Fe	Fe/SiO_2	Fe/Al_2O_3	%Fe recovery
8–15	0·1–0·2	Classification	15–31	1–1·5	1–3	40–85
15–20	0·2–0·3	Classification	28–32	1–1·5	2	44–76
		Magnetic	29–42	0·5–2	4–7	77–89
20–30	0·4–0·6	Classification	37–39	2–5	2·5–4·5	55
		Magnetic	45–50	2–3	5–7	57–73
30–35	1	Classification*	38	3	7	71
30–45	1–2	Magnetic	38–50	3–4	6–8	71–96

* One result only

(*a*) the laboratory separator and (*b*) a 'Rapid' OG type separator. The results are summarized in Tables IX and X.

In both cases, an acceptable concentrate has been produced, but it must be emphasized that the analysis of the head was considerably better than that of the sandstones examined from the Northampton area. Hence the amount of concentration required to improve the material was not as great. Nevertheless, these two results are reasonably encouraging, as in addition to the most favourable iron/silica ratio so far achieved in a concentrate, there are iron recoveries of 90% and 96% respectively.

DISCUSSION

In attempting to assess how much concentration has been achieved, one factor which is of importance is the iron/silica ratio in the concentrates; this should not be less than 2:1, and preferably higher if the slag volume is to be kept within reasonable limits.

Figure 4 shows the relationship between the iron analysis of the head samples and the iron/silica ratio in the concentrates. Despite considerable scatter in the points, there is a trend towards higher iron/silica ratios as the Fe content of the head samples increases. This is more apparent with the classification tests where the experimental conditions were constant than with magnetic separation where different separators were used.

Table XI gives a fuller, if rather more general, picture of the trends in concentration by the two methods of classification and magnetic separation. Broadly, magnetic separation has given concentrates with somewhat higher iron analyses and with better iron recoveries. The iron/silica ratios are similar for both methods but there is generally better rejection of alumina using magnetic concentration.

Classification has the merit of simplicity, and improvements in the results depends largely on adequate liberation of the iron oxide and quartz by suitable grinding methods. The fact that alumina also tends to concentrate in the finest fractions (Table II) suggests that the iron/alumina ratio could be improved without too much iron loss by rejecting the finest fractions, say, below 5 micrometres. There would, in practice, be no difficulty in rejecting this fraction.

Magnetic concentration, on the other hand, is more complex since a roasting stage must be introduced. The justification for such a process can only lie in a higher grade concentrate with better iron recovery than is possible by the simpler method. To some extent this has been achieved.

The dry separation methods used were not very efficient since there was always entrapment of non-magnetic particles by clusters of magnetic particles. Better dispersion of particles would encourage cleaner separation and this would more easily be done with the wet methods.

Summarizing the results, it is clear that while there has undoubtedly been some improvement in the grade of the material, the concentrates are only of ore grade in a few cases. Where the iron content of the raw material is 20% or more, it should be possible to make an acceptable concentrate without too much difficulty, but below this figure the iron/silica ratio was not improved sufficiently.

CONCLUSIONS

1. While there is no difficulty in removing a large part of the silica as quartz by ore-dressing methods, the alumina as clay tends to remain with the iron, especially when the ironstone is concentrated by classification.
2. Reduction roasting followed by magnetic separation has yielded somewhat better concentrates in terms of both iron content and iron recovery than classification.
3. The dry magnetic concentration methods used were not very efficient owing to the poor dispersion of magnetic and non-magnetic particles. Better results might be achieved with wet separation, but would involve problems of dewatering.
4. Concentrates of ore grade were only possible where the iron content of the head sample exceeded 20%, the best concentrate containing about 50%Fe, 16%SiO_2, and 7%Al_2O_3.
5. Further small-scale but continuous experiments are needed to evolve the most efficient grinding technique, the precise size cuts for classification, and the best method of magnetic separation.

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Discussion at the Autumn General Meeting 1960

The Autumn General Meeting of The Iron and Steel Institute was held on Tuesday and Wednesday, 29 and 30 November 1960 at Church House, Great Smith Street, London SW1. At the technical sessions on fluid flow, held on 30 November, the President (Mr W. F. Cartwright) was in the Chair. The papers presented have already been published in the Journal. *Discussions at the first two technical sessions are given below. Discussions at the other sessions will be published in a subsequent issue of the* Journal.

Discussion on fluid flow in furnaces and converters

SESSION I

This discussion was based on the following papers (dates of publication in the *Journal* are given in parentheses):

'Flow patterns in three-dimensional shapes', by *N. P. Bacon* (Guest, Keen Iron and Steel Co. Ltd), *J. H. Chesters*, and *I. M. D. Halliday* (United Steel Companies Ltd), (1960, **195**, July, 286–292).

'Aerodynamics of the open-hearth furnace as a means of controlling the processes of combustion and heat exchange,' by *M. A. Glinkov* (Moscow Steel Institute), (1960, **196**, Sept., 1–14). [When this paper was presented a film was shown.]

'Protection of open-hearth furnace roofs by an auxiliary jet', by *J. V. Edwards* (Steel Company of Wales Ltd), (1960, **196**, Nov., 289–294).

Mr **R. W. Evans** (Steel Company of Wales Ltd): Before going on to deal with these papers in detail, I shall make a few remarks in general on fluid flow furnaces. This symposium is timely because it occurs at a moment when the OH furnace is being challenged by the basic oxygen steelmaking processes. The challenge is based on, for instance, lower construction, maintenance, and operational costs for the basic oxygen process. But the OH furnace has obviously one great advantage, the flexibility with regard to the amount of pig iron or hot metal and scrap which it can deal with. Indeed, it can go from 100% of hot metal to 100% of scrap. Even so, if the OH furnace is to consolidate its position, then its rate of production in tons/h will have to be increased, and this must be achieved without excessive wear on the refractories, with in other words, a low refractory maintenance cost.

Generally speaking, high production and low maintenance costs are not compatible. The refractories of the furnace limit the temperature of the gases with which they are brought into contact, and we must try to arrange things in such a way that the high temperatures associated with very great heat releases in the furnace may be used in heating and melting the charge so far as possible without subjecting the refractories to temperatures and erosion effects which are above their ability to withstand and sustain. Indeed, we want to avoid the sad state of affairs which was described in a paper on OH practice given to this Institute many years ago, when it was said 'While the roof could be melted with the greatest of ease, the same could not be said of the charge'.

If on a furnace which is subjected to ever increasing rates of driving the roof eventually becomes the keypoint in the life of the campaign, then if it is a silica roof obviously the first thing to do is to put on basic refractories instead of silica. It must be said that if the flow pattern in the furnace is not right, even with basic roofs severe troubles will occur, and on basic roofs these are far more costly than on silica roofs. It is, therefore, essential with a basic roof to try to get the flow pattern in the furnace absolutely right, and as has been shown today, one of the most important methods of studying these flow patterns is first of all to find out on a model roughly what may be expected and then try to apply it to a full-scale furnace.

In an OH furnace there are in fact a number of different conditions to deal with. For instance, the furnace may have to use high hot metal, or it may have to use high scrap. On the one hand, the furnace may be fired with pre-heated gases, such as producer gas or mixed gas; Professor Glinkov's paper was more or less devoted to the use of mixed gas. On the other hand, one can use liquid fuels, tar, or oil, or compressed coke-oven gas. These are different conditions which have to be taken into account when thinking of the best way of organizing the flame in the furnace.

It is a fact, I think, that there are large OH fixed furnaces, certainly on the Continent and possibly in Russia, using high percentages of scrap (around 70–75% of scrap), using no oxygen but obtaining very high tons/h production figures and, this is the important point, with very long roof lives of 800–1000 heats, with a proportionately high front-lining life. It is that sort of achievement that is going to consolidate the OH furnace in its present position.

This sort of problem confronted the manufacturers of gas turbines, and no doubt it was quite as acute for them, but the problem was solved. In an OH furnace, if the roof wears very badly the furnace has to be put out, and production drops. If the jet engine in an aeroplane fails possibly the aeroplane and its contents drop, and the whole world gets to know about it. It is something that simply must not be allowed to happen. Most of the problems have been solved with the internal combustion turbine, and it would seem that they are not by any means incapable of solution in the OH furnace.

We have had three papers this morning: two deal largely with the flow patterns in confined spaces on a cold model, and Mr Edwards' paper is an application of cold model work to a full-size furnace in operation.

Dr Chesters' paper shows us what to expect from experiments on various three-dimensional shapes: his flow patterns will be most useful for application for the OH furnace; his diagrams on other shapes give a lead to what is likely to occur in other metallurgical furnaces and containers.

At this point, I should like to say how interesting the Russian film was, and I congratulate the Russian gentlemen who were associated with its production on the excellent photography and the very interesting way in which they were able to show these flow patterns. After seeing that film, I think we cannot be surprised if we do get a little wear on our furnaces. The question is, of course, how we are going to stop it. One thing I noticed in the slow-motion part of the film was that the length of the entrainment area in the flame was roughly two-thirds the length of the furnace, and I think that

in Dr Chesters' paper also it was shown that the entrainment area was roughly two-thirds of the way along.

Dr Chesters' excellent isometric diagrams show extremely well in a three-dimensional way what happens to the flows of gas. In particular, they show the little swirls which do not always come out in a photograph or on a two-dimensional basis.

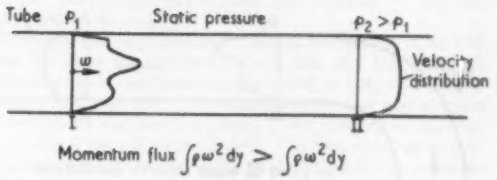
Professor Glinkov's paper is a masterly attack on the problems presented by the OH furnace, in particular with regard to flow patterns. He has taken into account a great deal of theory, and the paper is an all-embracing one which touches on almost every aspect of the way the gases come in, behave inside the furnace, and go out. Professor Glinkov has summarized the problem on the first page of his paper, when he says that the aerodynamics of flames is a question of the greatest importance, as it governs, first, mass transfer processes which ensure heat generation; second, the removal of cooling gases from the bath surface and their replacement by fresh portions of a burning stream; and third, mass transfer processes associated with bath-fed oxygen for technological purposes and the removal of the gases released from the bath surface.

These are the main problems in trying to get an OH furnace to work fast. If these are solved, we can ensure the fastest possible transfer of heat and oxygen to the bath, resulting in high melting and refining rates.

Since it is necessary to preserve the refractory brickwork in the furnace, the relationship between the kinetic energy of the incoming mixture of fuel and air and the kinetic energy of the outgoing waste gases becomes very important, and it is shown by Professor Glinkov that the greater the difference the greater the degree of recirculation. Is this a good or a bad thing? This is one of the questions to which we would really like to know the answer. Are we trying to get more recirculation, or is this a matter of degree? Perhaps we would like to see a little more, but not too much, now that we know better how to control it. Certainly, the higher the furnace pressure the greater the wear on front and back linings, and possibly the greater the wear on the roof; but do large OH furnaces which average 800- or 1 000-heat roof lives at high rates of production experience much recirculation, or are these high lives achieved at the expense possibly of some air infiltration through the doors which may increase the fuel consumption?

I also agree with Professor Glinkov in saying that the maldistribution of wear on an OH furnace roof may easily be caused by non-uniform admission of the combustion air, and I think that he is probably right in concluding that non-uniform admission of air is more likely to happen with two uptakes than it is with one; but if this is so, can the two-uptake designs be improved, for instance by reducing the size as is practised in the Maerz furnace? We know of Maerz furnaces with very high rates of production and with good furnace lives in terms of roof and front lining, and one would like to know whether, in Professor Glinkov's opinion, this is associated with a reduced size of the two uptakes. One used to be told that a simple rectangular or box type of furnace was the best all-round design and the simplest to build, but most designs incorporate a sloping back wall, and one can understand the original idea of the sloping back wall; in these days, is the sloping back wall really so necessary? If it is not necessary, then a considerable saving could be made in the furnace construction costs. There would be a narrower roof, and one would think that this would represent a considerable saving. Perhaps Professor Glinkov would let us have his comments on that point.

Mr Edwards' paper shows how ideas derived from a cold model can be applied to the correction of undue or bad local wear on a roof of an OH furnace, and the method described undoubtedly helped in prolonging the life of the roofs. Nevertheless, the fact that heavy wear was experienced in this particular part of the roof may show that there was, in fact, a maldistribution of combustion air as it came into the furnace, and this might be a fundamental fault in the design of the furnace. One wonders whether one should not devote perhaps a little more thought and attention to how that situation can be corrected rather than to applying a later corrective, such as described by Mr Edwards, to try to take care of what was originally a bad situation.



A *Tube showing very bad distribution of velocity*

Dr **J. H. Chesters,** in reply: I was glad that Mr Evans stressed the importance of flow pattern in all-basic furnaces. The view is occasionally taken that chrome–magnesite bricks being far more refractory than silica need not be treated with any particular respect and, for example, that roof pyrometry is no longer necessary. Our own experience suggests that this is far from true and that the maintenance of a reasonable roof temperature, say below 1 730°C rather than the 1 650°C specified for silica, together with the minimization of iron oxide deposition, are extremely important if good roof life is to be obtained. The importance of flow pattern was well illustrated on our Templeborough furnaces when a change was made from single to twin burner operation. On silica-roof furnaces this resulted in a complete shift in wear pattern: with a single burner the most severe attack was adjacent to the back and front walls, while with twin burners it moved to the roof centre. When similar trials were made with an all-basic furnace the same shift occurred. It was further shown that there was a strong correlation between iron oxide deposition (itself a function of flow pattern) and the localized rates of wear both on silica and basic furnaces.

Turning to recirculation, we have spent a great deal of time in recent years trying to decide whether this is a good or a bad thing. The problem is immensely complicated, but we would I think lean at present towards the view that recirculation in OH furnaces is undesirable and should be minimized. The bases for this view are as follows:

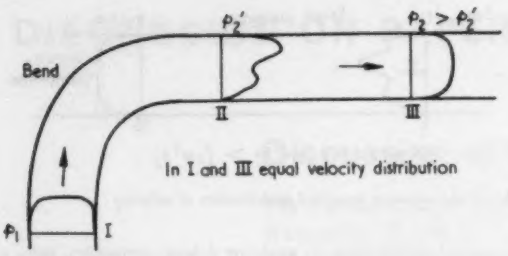
(i) The iron oxide deposited on roofs is brought there mainly by recirculating gases. This can be clearly shown by alumina probes pushed through the roofs, which generally show blackening on the side opposite to that from which the flame is coming.

(ii) Recirculation of burnt products that have already given up a substantial amount of their heat to the charge must surely reduce the flame temperature at the incoming end and, therefore, the difference in temperature between flame and charge, vital to heat transfer by radiation.

Such recirculation can of course have other peculiar effects; it may, for example, control the rate of soot formation and, therefore, also the radiation distribution. This latter point is at present being studied by a United Steel Co.'s bursar working at Sheffield University.

Dr **M. Hansen** (VDEh Energie- und Betriebswirtschaftstelle) I should like to comment on the papers of Dr Chesters and Professor Glinkov. In reading those papers I found that the narrow connexion between static pressure and momentum flux was neglected, but today I find that the Russian research workers have widened their work in that direction. However, I think it might be useful if I were to make some remarks to describe the narrow connexion between static pressure and momentum flux.

The basic law is Newton's law of actual equal reaction, and I want first to give a simple example. Figure *A* shows a tube and a very bad distribution of velocity; in section I and afterwards in II there is the velocity distribution equalized after a longer distance. Here the momentum flux $\int \rho w^2 dy$ is lower.



B *As* A, *with bend*

So there must be a rise of static pressure to give a balance of forces between the two sections shown. Afterwards surface friction begins to preponderate and there is a decrease of the pressure.

I can explain this further by giving another simple example. Figure *B* shows a bend, and one has to measure the pressure that is lost. The velocity distributions in sections I and III are equal. The static pressure p_2' is lower than p_2 because of the higher momentum flux of the biased velocity distribution generated by the bend in section II compared with III. The pressure difference p_1-p_2' is much greater than p_1-p_2, the real pressure lost of the bend.

For further explanation of this point I refer to a report[1] in which further examples are treated, especially concerning industrial furnaces.

In his paper Professor Glinkov discerns two kinds of turbulence. In my opinion there is no basic difference. We know the wall turbulence from the well-known experiment of Reynolds. It is going out from the walls. The free jet generates vortices of the free turbulence, and the vortices arise in every case where you have areas of different velocities. Also, if you have an obstacle in the fluid you will find that behind it there are areas of discontinuity and the vortices of free turbulence will arise.

I find no difference between these two kinds, from the free jet and from an obstacle, and the difference between this kind and wall turbulence is also not so great, because all kinds of turbulence have the same attributes: transfer in every direction of momentum, mass, and heat.

Dr **Kesterton** (Steel Company of Wales Ltd): I should like to express very great admiration for Professor Glinkov's paper. It represents clearly an extremely expert, comprehensive, and exhaustive investigation of the aerodynamics of the OH furnace, with the extremely practical objective in view of improving the heat exchange between the flame and the charge.

Professor Glinkov emphasizes early in his paper that the possibility of increasing the mean heat input to an OH furnace is associated in the closest possible way with the acceleration of the heat exchange processes, which latter are connected with the organization of the combustion processes and movement of gases. In other words, transfer of heat to the charge is of vital importance.

In this connexion, I should like to state the following case with respect to heat exchange: when fuels such as oil, methane, etc., are burnt completely with oxygen, the products of combustion remain dissociated to a considerable extent. Fuel oil, for example, when burnt with oxygen produces a maximum flame temperature of 2800°C, and of the total heat present in the flame, 56% is present as latent heat of dissociation. When such a flame strikes the cold surface of charged scrap, the latent heat present in the dissociated products of combustion should be released at the surface of the scrap, with extremely efficient transfer of heat from flame to scrap. This would be an important method of accelerating the heat exchange process.

Professor Glinkov's paper describes work in OH furnaces with enrichment up to 40% oxygen, and possibly therefore the Professor will feel able to extrapolate the data to give some answer to the problems of burner and furnace design when burning the fuel completely with oxygen.

Presumably the flames would be very short, and in any case the flame should strike the scrap as soon as combustion is well advanced in order to transfer the latent heat of dissociation. Should, therefore, the fuel and oxygen be introduced solely by means of roof burners? Alternatively can there be or should there be supplementation from the fuel burners in the pot ends? What is likely to be the best distribution of roof burners? Should there be an equal number in each half of the furnace, with reversal in the normal manner? If the burners and their positions are designed to effect maximum heat transfer by the transfer of latent heat, what is the resultant effect on other important factors stated by Professor Glinkov, particularly that associated with gas dynamics, principally the desirability of ensuring a good coverage of the bath by the flame? Would this be important, however, during scrap charging? What is the effect on furnace design? Is the present design the best for such an operation? Should the roof be raised considerably?

There are many problems of this nature; I should like to ask Professor Glinkov whether, from the work he has done, he can give any lead to us on what is the best course when using oxygen for complete combustion of the fuel.

AUTHORS' REPLIES

Mr **Edwards** wrote in reply: In reply to Mr Evans, it must be remembered that erosion is a result of recirculation, and this is largely a function of the use of a high momentum fuel jet and a limited amount of combustion air.

The furnace must be symmetrical, since it is a reversing furnace, and this condition coupled with the flame momentum and combustion air requirements obviates the possibility of eliminating recirculation. Even if the furnace were not reversing, and so did not necessitate symmetry, it would be extremely difficult to eliminate recirculation entirely, particularly in view of the variation of flow rates during operation.

It is, of course, desirable to minimize refractory wear by correct design and adjustment of operating factors, e.g. burner direction, as far as this does not affect facility of construction and maintenance. However, while agreeing with Mr Evans, I feel that under some circumstances a minor addition, such as an auxiliary jet, to the furnace ancillaries would be less expensive, more effective, and be less of hindrance to construction and maintenance than major complications in furnace design. It must be remembered that in the extreme case, a furnace designed with the sole aim of minimizing recirculation would not be of simple shape.

Professor **Glinkov** wrote in reply: I should like to express my thanks to Mr Evans, Dr Hansen, and Dr Kesterton for their flattering appraisal of my paper and the valuable comments they made on it. By way of amplification I would make the following observations.

Recirculation of gases by jets in the working parts of furnaces seems to be unavoidable. Tests have shown that about 90% of the initial energy of the stream is expended in recirculation and only 10% in overcoming the outgoing resistance and the counter-pressure. This distribution is almost entirely independent of the height of the combustion zone of the furnace. However, during the circulation of the gases through a combustion zone of small depth, recirculation can be reduced to a minimum, and the energy of the stream is then expended on overcoming the turbulence between the stream and the back flow. The proportion of recirculation, i.e. the relation between the quantity of gases across a section of the stream and the initial gas input, depends basically on the initial momentum of the stream, and partly on the energy factor (f_E) and the height of the combustion zone. The proportion of recirculation decreases if the stream is made to strike flat against the wall or the bath.

Has recirculation any use? Where it is required to have equal gas temperatures in heating zones, then, depending on the size of the furnace, recirculation is useful, since it prolongs the heating. The stronger the recirculation, the quicker the

individual flame jets merge. In OH furnaces the role of recirculation is considerably more complicated: it can slow down or speed up wear of the lining on the roof and walls. Obviously it would be better to have a screening layer of motionless gases at a lower temperature than those in the flame. Since this is impossible, recirculation is unavoidable and must be utilized. With proper organization of recirculation, the returning stream, going along the roof towards the centre, feeds the exhaust stream, i.e. the cooled products of burning over a wide area. For this the circulation zone should begin near the exhaust ports. The unequal nature of recirculation leads to uneven wear on the roof brickwork. The slower the circulation stream in the return branch along the roof, the better. For this the height of the level area must be adequate, since speeds in the circulation zone decrease as its volume increases.

Determination of the best form for the hearth of an OH furnace is a complex matter. Investigations so far carried out are inadequate. We think that in the melting zone, a fixed heat exchange pattern obtains, characterized by the fact that the temperature range in the flame is different from that in the gases around it.

In the long run the effectiveness of an OH furnace is determined by the ability of the flame to transfer heat to the mixture and the bath, and to act as an oxidizing agent. Thus everything which affects the positioning and layout of the jet and its temperature, also affects the work of the furnace as a whole. The shape of the hearth affects the circulation zone and indirectly the flame, i.e. the heat and heat-exchange processes.

We consider that the streamlining of the inner lining of the hearth exerts a favourable influence on the evenness of wear of the brickwork and reduces the effect of secondary flows directed via the walls on to the base of the flame. These secondary streams, arising from the impact of the flame on the reflector of the bath, will flow smoothly into the main stream (flame) and the circulation zone if the inner surface is streamlined, achieving this without producing any unwanted deformation of the flame. From this point of view, an arched roof is preferable to a flat one and gently sloping walls are preferable to sharply sloping or vertical ones. Maerz-Belens walls, for instance, are preferable to ordinary sloped ones. (This is merely from the aerodynamic viewpoint and does not take into consideration any structural, practical, or economic aspects.) A particular example is the long life of the wall and roof linings with Maerz ports. We consider this to be a result of directing on to the roof air streams, which in flowing partly along the roof and walls protect them from the action of the hotter and more erosive gases in the flame. It is true that this effect depends on the exit speed of the air from the vertical channels, i.e. from their sections. In all other constructions the airflow principle is different. I doubt whether simplification of OH furnace construction by replacing semi-inclined walls with vertical ones leads to better furnace operation.

As was emphasized in our paper, the uniformity of heat distribution in the flame of an ordinary OH furnace does not satisfactorily ensure even heating of the bath. This seems to be the basic shortcoming of an OH furnace, and it needs to be overcome. The ideal solution to this problem seems to be to feed heat and oxygen straight on to the surface of the mixture or to the bath, thus bringing about a directed heat exchange. However, the only simple solution, constructionally, is to use high-calorie cold fuel (oil, natural, or coke-oven gas), and artificial oxygen. In 1954 four gas–oxygen burners were fitted in the walls of a 200-ton OH furnace and using a mixture of gas and heated air, completely controlled temperature and oxidation conditions were achieved in the flame layer immediately next to the bath surface.[2,3] As the carbon consumption increased (reaching 3·0–3·5%/h) the feed of gas to the burners was cut off and oxygen alone was supplied to burn up the CO coming out of the bath. The resultant heat surplus satisfied heat demands for 20–30 min. Under these conditions the output of the OH furnace reached 40–50 tons/h using $0{\cdot}6.10^6$–$0{\cdot}65.10^6$ kcal/ton fuel and 60–65 nm³/ton oxygen. A very similar process has been carried out recently in France[4] and the USA[5] using high-calorie fuel and oxygen in burners, directed on to the roof.

The theoretical explanation of this is as follows: in an OH furnace the heat requirements of the mix and the bath and heat losses of the hearth are compensated on the one hand by the heat introduced into the melting zone by fuel and air, and on the other by the positive effect of the melting of pig iron and burning of the CO on the hearth. The heat requirements in the melting zone for burning the fuel and additives is represented by Q_Σ, giving

$$Q_\Sigma = Q_H + Q'_m - Q'_w + Q_{ex} + Q''_m - Q_{end} - Q''_w$$

where: Q_H is the fuel heat kcal/h; Q'_m the physical heat of the fuel and air (kcal/h for burning); Q'_w the chemical and physical heat of the gases leaving the burning zone resulting from fuel consumption, kcal/h; Q_{ex} the heat of the exothermic reactions, kcal/h; Q''_m the heat of the air going to oxidize the pig iron, kcal/h; Q_{end} the heat of the endothermic reactions kcal/h; Q''_w the chemical and physical heat of gases leaving the burning zone resulting from the burning of the mix, kcal/h.

The process of heat generation from the mix can be expressed by the coefficient of heat generation

$$A = \frac{Q_{ex} + Q''_m - Q_{end} - Q''_w}{Q_\Sigma}$$

Thus the heat generation coefficient characterizes that part of the heat obtained from heating the pig iron in an envelope of heat, assimilated by the metal and slag and lost in the area around.

The meaning of Q''_w is determined by the amount of CO_2 formed from burning carbon in the bath and by the amount of nitrogen uniting with oxygen in the atmosphere of the furnace used for reducing the mix. If it is assumed that the heat effect of the reduction of ore to FeO is Q_{end}, then it is easy to calculate that the heat produced by burning carbon with the oxygen in the ore is

$$Q_{ex} - Q_{end} - Q''_w \simeq 2700 \text{ kcal/kg C};$$

that produced by burning carbon with oxygen in the air heated to 1200°C is

$$Q_{ex} + Q''_m - Q''_w \simeq 4700 \text{ kcal/kg C};$$

that produced by burning with pure oxygen blown into the bath is

$$Q_{ex} - Q''_w \simeq 6900 \text{ kcal/kg C}.$$

If the heat produced by turning CO into CO_2 is taken as ~5700 kcal/kg C, then it follows that without burning CO in the region around the bath, the burning of carbon by the oxygen in the ore will need heat from the flame in the order of 5700–2700 ≃ 3000 kcal/kg C, and by the furnace atmosphere 1000 kcal/kg C. Inasmuch as the powerful heat generation from Si, Mn, and P (reduction of phosphorus ore) has an effect only on the initial part of the melt, the importance of burning CO over the bath becomes obvious. In addition, the burning should take place under conditions favourable to transference of the heat formed to the bath, i.e. near the surface of the bath. Burning CO at some distance from the surface of the bath leads to overheating of the brickwork and ports and is almost ineffective in speeding heat assimilation.

Thus the heat assimilation of the bath is dependent on three heat sources: (*a*) combustion of the mix inside the bath, (b) burning of fuel over the bath, (c) burning of CO from the bath over the bath. When burning carbon the first source has a weak but definite effect. When burning Si with the oxygen in the ore, an effect of 1100 kcal/kg Si, will be produced; and with atmospheric oxygen, an effect of 2900 kcal/kg Si. It must be borne in mind that with large OH furnaces working on the scrap–ore process, the portion of chemical heat in the pig-iron mixes accounts for about 25% of the heat produced. About 80% of this heat comes from the carbon and only about 20% from the Si, Mn, etc. Besides, as has been shown, Si and Mn are burnt up while the pig iron is being poured during the first

part of the melt, so that the effect of heat thus produced is limited.

Even with the increasing importance of heat generation from carbon, the OH furnace remains essentially a heat transferring apparatus, merely a means of heat assimilation changing the CO from the bath.

At the same time the intensity of CO production from the bath as a heat source plays a part in heating the bath with atmospheric oxygen, i.e. it depends on the reducing capabilities of the furnace and these, under other similar conditions, depend on the organization of the flame both from the point of view of feeding the bath with oxygen and of burning CO from the bath over its surface.

As is well known from experiments using natural gas instead of oil, even though a good flame is produced, furnace output decreases because of a lowering of the reducing capacity and of the amount of CO produced from the bath. Only special arrangements for the flame can overcome this deficiency. A high reducing capacity and means of burning CO over the bath, as has been shown above, significantly increase the productivity of the furnace and reduce fuel consumption.

Thus in modern high-speed OH furnaces, particularly those of large capacity, the provision of effective conditions for burning CO from the bath is most essential, and the use of oxygen in this connexion is extremely effective. It is still necessary to burn CO even when oxygen is fed straight into the bath to burn the mix. It follows from the figures given above that the oxidation of CO gives 6900 − 5700 = 1200 kcal/kg C, and therefore does not obviate heating the bath, particularly when oxygen is fed in with steam. The provision of these necessary means for the burning of CO and heat transfer is much easier in a flame OH furnace because of the build-up of the bath surface. In this process the OH furnace is superior to oxygen converters, particularly of the LD process. It is necessary to find a solution to the question of the comparative capability of an OH furnace and an oxygen converter. An effect can be produced even without using oxygen. In an oil-fired furnace with ports designed to deflect the air onto the surface of the bath the output of the furnace was raised by 6–7% and the amount of fuel consumed was 105 kg/ton steel instead of 130 kg/ton.[6]

As suggested, even better results can be obtained with simultaneous working of the ports.[7] It was stated before[6] that as the volume of the furnace increases, the size of the bottom area decreases per ton of charge (S/T), i.e. the specific heating surface decreases. Inevitably the heat transfer from the flame to the fuel becomes less efficient, but this may have little bearing on the heat transfer due to burning CO from the bath if measures are taken to ensure uniform feeding of oxygen. This is explained by the fact that the fuel comes from a port on one side and the CO is spread equally over the surface of the bath.

Despite the worsening of heat-transfer conditions, the increase in furnace capacity was very effective; among the causes of this are the raising of the coefficient of heat generation (A), and in particular the establishment of CO burning by better organization of the flame. However, we submit that the one-sided heating of one of the larger furnaces (600 tons capacity and higher) cannot produce the right heat-generation conditions, and therefore further increases in the capacity of furnaces with only one-sided heating may not give the expected results.

In connexion with this it is interesting to consider the dynamics of change in the coefficient of heat generation during an OH melt. The mean value of A for modern large OH furnaces working on the scrap process is 0·2; for scrap–ore A = 0·25–0·30; using oxygen A = 0·4–0·45. For comparison, in old slow OH furnaces this value was not higher than 0·05–0·1, and for converters and rotor furnaces A is obviously 1. It follows that the best utilization of oxygen in OH furnaces is achieved by feeding floor jets from the side of both ports, with the use of butterfly valves in the centre: the products of combustion are swept out through both ports; or by an oxygen feed through burners with an orthodox movement of gas through the furnace. The bigger these burners the better, since the surface of the bath is better covered with flame. It must be borne in mind that the greatest effect is achieved during the violent production of CO, i.e. during melting. Effectiveness during feeding and heating of a hard mix depends entirely on the quality of the scrap and the speed at which it melts.

Air enrichment by feeding oxygen into the torch is not the best method of using oxygen and the desired effect can be achieved in other ways. Heat generation by blowing oxygen on to the bath is ineffective. In fact for 1 nm³ oxygen forming CO out of carbon, 1200 kcal/nm³ remains in the bath, and when CO becomes CO_2, 6000 kcal/nm³ remains in the melting zone. Besides, blowing oxygen into the bath has a bad effect on the life of the furnace. The role of the chemical heat of the products of dissociation cannot, in my view, be specified. Chemical heat exerts an effect analogous to that of physical heat, arising from heated fuel or air, inasmuch as it is not related to an increase in the volume of the products of combustion.

We are convinced that in the not too distant future regenerative OH furnaces will be replaced by recuperative furnaces or furnaces without air heating, but constructed to make better use of oxygen.

In conclusion we would like to say in reply to Dr Hansen that our views on the nature of turbulence do not contradict the classical notions. The nature of turbulence is obviously fixed, but the scale of it can change (according to Prandtl it is '1'): large-scale turbulence usually arises from flow round the obstructions in the ports, and this is undesirable because of its effect on the flame. Investigations in this part of the USSR are directed at determining the true effect of the shape of gas and air channels in the ports on the organization of the flame.

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SESSION 2

This discussion was based on the following papers (dates of publication in the *Journal* are given in parentheses):

'Application of flow research to industrial furnaces with particular emphasis on soaking pits', by *H. Boenecke* (Ofenbau-Union GmbH, Düsseldorf), (1961, **197**, April, 283–295.)

'Application of aerodynamic design to the "U-fired" soaking pit', by *J. H. Richards, D. K. Griffiths*, and *C. W. Sidwell* (United States Steel Corp.), (1961, **197**, Feb., 117–121).

Mr **A. E. Pengelly** (United Steel Companies Ltd): We should be pleased that serious model-making techniques are evidently being used for real furnace design by commercial builders and by professional steelmakers. May there be more and more.

But before we make any more, I suggest that we look carefully at similarity criteria. In both papers, mention of similarity criteria is vague and to a degree misleading. Dr Boenecke gives some references, but none of these treats the subject in detail. Therefore I should like to recommend Johnstone and Thring's excellent book.[1]

Both papers imply that Reynolds similarity is all-important. Dr Boenecke qualifies this and admits that he had to reduce his Reynolds number, but that since it was still well above 2300 this did not matter. He observes, however, that using Reynolds similarity, 'model results can be transposed without further adjustment to fit the full-sized furnace'. I submit that this is untenable.

On page 285 of his paper, Mr Boenecke is at pains to explain the major effect on flow pattern of changing nozzle size; but a little elementary rumination makes it evident that since he works at constant total flow the chamber Reynolds number is unaltered by this trick.

In parallel, Richards *et al.* say that they used momentum similarity. This is either vague or quite definitely wrong, and if the latter, then the results reported bear such a good relation to the real thing only because the slow moving gases in an almost isothermal soaking pit allow gross liberties to be taken without protest. It is interesting, however, that in their last paragraph they mention making major alterations to their final plant burner ports, the main subject of their model work.

A similar argument applies also to Boenecke's soaking-pit results, but certainly one cannot take such liberties with the pusher furnaces that he discusses in detail.

The criterion that matters is the mixing parameter which ensures that the degree of entrainment either of fresh air of or recirculation products is properly modelled. This criterion, sometimes called the Thring–Newby parameter, is based on the fact that a jet entrains as a function of its momentum and its density.

Table 1 shows roughly how. Figure *C* shows the static pressure distributions in a $\frac{1}{10}$ scale model and its parent pusher furnace compared when this parameter, and rough Reynolds similarity, are used. Evidently there is a good comparison between the two.

I was glad to hear Dr Hansen stress what I think is implicit in Mr Boenecke's paper, namely: that static pressure really counts in a furnace and is something that we should watch carefully.

Figure *D* shows the effect of departing from the mixing criterion. The dotted lines show this. The line in the model, line no.1, is the curve of Fig.*C*.

I should like to ask a question about the static pressure diagram given by Mr Boenecke, where static pressure distributions are shown very similar to Fig.*C* and Fig.*D*, except that the burners point the other way. Dr Boenecke says that the pressures agree with calculated ones. Will he please expand this, because the possibility of calculating pressure distribution in a furnace with a bent flow actually going backwards from the way it started is very exciting?

It is clear from Fig.*D* that pressure recovery is quite different as one plays with burner variables; will the authors express their views on the limit of complication which is useful in models? The second paper in particular stimulates this question, since the authors have taken the trouble to model a complicated regenerator system. Was it any use? We have a philosophy that if the viscous pressure drop in a system is more than a tenth of the input momentum flux, then the results will be of no quantitative use. Have the authors a view on this?

Table 1 Mixing similarity

From the theory of jet mixing

$$Mx = k\sqrt{G\rho x}\, x$$

replacing G by the burner variables and dividing by Mo

$$\frac{Mx}{\mathrm{Mo}} = k'\sqrt{\frac{\rho x}{\rho o}}\cdot\frac{x}{do}$$

For the same degree of mixing Mx/Mo in the model and the furnace, and assuming constant k' to be the same in each case

$$\frac{dom}{dof} = \frac{xm}{xf}\sqrt{\left(\frac{\rho o}{\rho x}\right)_f}$$

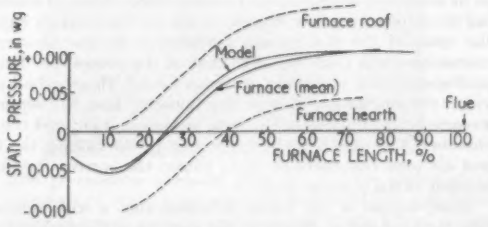
In self consistent units
M = Total mass in the jet
G = Momentum flux through burner
ρ = Density
d = Nozzle diameter
x = Linear dimension
k and k' are constants
Suffixes refer to model (m), furnace (f), burner (o), and point (x)

Mr Boenecke describes a very pretty two-dimensional system for getting quick ideas in a water trough. I suggest that this can be dangerous, and would mention work by Bacon and Brooks of GKN and United Steel respectively, who demonstrated the enormous effect of introducing contours on the bottom of the tray. They called their system two-and-a-half dimensional because the vertical was on a different scale, and they showed that as $2\frac{1}{2}$ approaches 3, the results improve.

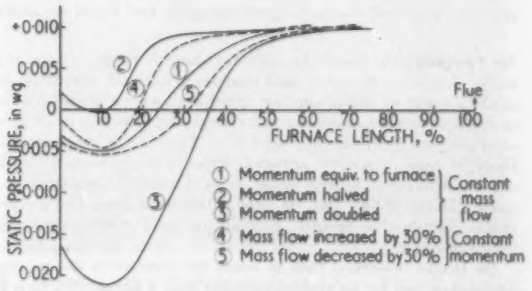
I was pleased to see mention in both papers of measurements on the plant. In passing, I note that Richards *et al.* did a trial on a soaking pit with five variables at two levels: 32 tests. Engineers who can do that successfully could probably have made the pit work without models at all!

In conclusion, I suggest that, however good model work is, it must be followed by plant trials, and that in these one's time is repaid handsomely by developing special instruments. In particular, time spent in building semi-automatic traversing and recording instruments both for model and plant work has been shown to be well worthwhile.

Mr **H. Boenecke** (interpreted from German): I should like to give a short reply to the criticism at the end of this morning's session. I was grateful for the criticism brought forward, because criticism is helpful and an incentive to push the work further ahead. I agree on all points with what Mr Pengelly said. It is certainly true that all the laws of similarity have to be observed if the results are to be compared between full-scale experiment and model tests. In fact, I wish to go a stage further. Not only do I agree with all the laws of similarity brought forward by Mr Pengelly, but I would even suggest that Mr Pengelly has forgotten one law. For the practical engineer there is a law number one, and that is the time factor. I come from an institution in which the most important duty



C *Comparison between static pressure distribution in $\frac{1}{10}$ scale model and pusher furnace*



D *Effect of departure from mixing criterion*

is to reach to results quickly, so that the results can be applied in the actual design of a furnace. I have been carrying out model tests for some 25 years and felt that I had learned in that time what laws and what factors could be neglected in order to achieve quick results. The purpose of my model test is not to achieve 100% coincidence between the model test and the full-size furnace; the overall task is to find out quickly what design factors should be followed in the execution of an actual furnace.

The department in which I work is subdivided into two groups: one that carries out the model test, and the second group that carries out the experiments on actual-size installations. We have found that the errors possibly committed in tests on full-scale furnaces are far larger and more important than those committed in the model tests. That is why, at the end of the paper submitted to this meeting, I enumerated a number of mistakes and errors which have been found in the actual-size plant, in comparison with which imperfections in the model tests decline in importance.

The questions asked by Mr Pengelly are at the moment being studied in their various parts. I will inform Mr Pengelly of my findings.

Dr **N. P. Bacon:** I do not think that Mr Pengelly's comments are quite complete. He is correct in stressing the importance of having the correct mixing conditions but not correct in assuming the same entrainment constant for flames as for cold jets. This equality of entrainment constants was assumed in the figure shown by Mr Pengelly but in the light of work by Hogg and co-workers[2] we are no longer able to accept this as correct. The rate of entrainment into a flame is appreciably slower than into an isothermal jet. In other words model work based on a simple momentum theory will show more rapid mixing than would be obtained in the full-scale unit.

Perhaps the simplest way to undertsand the use of the Thring–Newby[3] momentum criterion is as follows: Take the full-scale furnace with all its temperature differences in the various parts and convert it into a modified full-scale furnace which is at a constant temperature throughout. Parts of the furnace must be modified in size to maintain the same momentum as before, e.g. in an OH furnace the oil/steam mixture is assumed to emerge from the burner at 1600° or 1700°C. The size of the burner nozzle must be considerably increased to maintain the same momentum as for operating conditions. In fact, the equivalent nozzle size, as it is known, is about 4in for a typical case. Having produced this isothermal full-scale furnace with its various distortions the correct model sizes are obtained by scaling down geometrically throughout. We have used this method during the course of model work on a soaking pit at Guest, Keen Iron and Steel Works. In this case we had quite big temperature differences between the inlet temperature of blast-furnace gas and the ambient gas temperature in the pit itself. We did mixing work with a simple geometrically scaled model which we expected to give results a long way from the truth. Then we used the Thring–Newby momentum criterion which resulted in considerable geometrical distortions. In this case it has serious consequences because the burner ports were quite large when compared with the dimensions of the burner wall. Results obtained from the full-scale pit were between those obtained using the two types of model.

Mr **Pengelly:** Dr Boenecke has said that shortage of time is a major factor in his work and that he is obliged, therefore, to neglect some of the similarity criteria which he would like to use. On the evidence that I have acquired, which is in general of a similar form to that shown in Fig. *B*, I suggest that if there is one similarity criterion that is all important, it is mixing criterion. All the evidence is essentially practical and quite clearly shows that if this criterion is used the proper static distribution results; if it is not used results are often badly in error.

Dr Bacon observed that in some circumstances the mixing parameter can be an embarrassment and I agree with him in the specific case of a model whose burner ports have to be distorted so much to fit the parameter that the geometrical similarity criterion is grossly distorted. Such gross distortion in general occurs with low velocity gas-fired systems, such as the soaking pit mentioned by Dr Bacon. Luckily, however, as I said earlier, under these conditions the system is quasi-isothermal and gross liberties can, as we have seen, be taken.

Recapping then, in all systems, with the exception of the above, the mixing criterion is all important, geometric and Reynolds similarity need some attention, and the whole thing then works if the viscous pressure drop in the system is small.

Dr Boenecke observed that with the availability of elegant model techniques it is possible to become so absorbed with model work that genuine engineering problems on the furnace are not accounted for. I quite agree and as I said earlier, model work *must* be corroborated in the furnace chamber. Dr Boenecke has shown us a number of very elegant non-quantitative model techniques which I think prove his point to the hilt.

Mr **Griffiths,** in presenting his paper, said: As the title of our paper implies, we hoped to present a discussion of the application of models to an engineering problem. Similarity criteria of flow-visualization techniques were not described extensively since the techniques used have been described elsewhere. The application of aerodynamic models as an engineering tool in the design of the U-fired soaking pit was very successful. We attempted to describe how the flow-model studies aided in the development of this soaking-pit design. We apologize that the brief comments on the similarity criteria used were vague and misleading. Further elucidation of the similarity criteria used in the flow models of the U-fired soaking pit is herewith presented.

In the model of the original design of the U-fired soaking pit, Reynolds number was used in the uptake and the downtake. The Thring–Newby parameter[4] was the burner–momentum parameter used to simulate the burner jets. The relationships were such that the jet fluid flow rate and the jet nozzle radius for the Thring–Newby parameter could be adjusted to satisfy the requirements for Reynolds similarity in the uptake and the downtake. Thus Reynolds similarity in the soaking-pit chamber could safely be assumed.

Simulation of the burner stream in the model of the revised U-fired soaking pit was not as straightforward. The air passes through a venturi before the firing port and the fuel is introduced through a slot at the side of the venturi. Such an arrangement departs from the basic assumptions of the Thring–Newby parameter: (a) negligible momentum of the air flow; (b) conservation of fuel jet momentum; (c) mixing by entrainment of the air by the fuel jet. In the revised U-fired soaking pit the momentum of the air flow is not negligible. The fuel jet may impinge on the wall opposite the burner slot in which case the jet momentum is not conserved. Mixing of fuel and air is not principally by jet entrainment. The Thring–Newby parameter was therefore impractical in this application. Strict Reynolds similarity in the firing venturi did not satisfy Reynolds similarity in the soaking-pit chamber or in the exhaust port. Nor is there a certainty that Reynolds similarity is sufficient in this non-isothermal system.

Reynolds number for a given flow condition is an expression of the ratio of the inertial forces (flow momentum) to the viscous forces. In the study under consideration, the Reynolds numbers were very large, and the viscous forces were assumed to be relatively insignificant. To solve the problem of simulating the intersecting flow streams in the burner–venturi region, the ratio of the fuel-stream momentum to the air-stream momentum was made equal to that of the prototype. This is analogous to the resolution of vector forces. This method provided the simulation of any directionality that the separate streams might impose on the total stream as it entered the pit chamber. The quantities of water used for simulating the fuel and air were calculated so as to obtain the correct Reynolds number at the exhaust port.

Observations of the model indicated that a wide range of flow rates caused no change in the analysis of the flow pattern in the pit chamber. Although exact similitude was not possible, the imperfect isothermal model permitted the detection of the

imperfections of the soaking-pit design and led to a satisfactory redesign.

In answer to Mr Pengelly's inquiry about the advantage of modelling the checker chambers on the soaking pit, there were none, except that flow directionality was obtained. No attempt was made to solve the problem of similarity since the variation of gas temperature was appreciable. In fact, strict geometrical similarity was not maintained.

We agree with Mr Pengelly's suggestion that model work should be followed by plant trials. We might also say that given sufficient time, new furnaces can be developed without the use of models as in the past. However, flow models provide a helpful engineering tool that facilitates the study of design changes.

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1. R. E. JOHNSTONE and M. W. THRING: 'Pilot plants, models, and scale-up methods in chemical engineering'; 1957, McGraw-Hill.
2. A. HOGG *et al.*: 'Use of aerodynamic models in the study of industrial furnaces, particularly open-hearth furnaces', The Seventh Symposium (International) on Combustion, 1958.
3. M. W. THRING and M. P. NEWBY: 'Combustion length of enclosed turbulent jet flames'; The Fourth Symposium (International) on Combustion, Baltimore, 1953.
4. M. W. THRING and M. P. NEWBY: 'Combustion length of enclosed turbulent jet flames', Fourth Symposium (International) on Combustion, 1953; The Williams and Wilkins Co.

Correspondence on the paper

Effect of Al and N on the occurrence of intergranular fracture in steel castings*

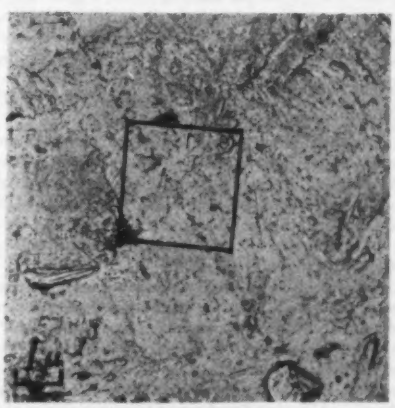
Mr **S. Hasabe** (Central Research Laboratory of Sumitomo Metal Industries Ltd, Amagasaki, Japan) wrote: I was interested to learn that intergranular fracture was influenced by AlN precipitated in the grain boundary of austenite. In my own investigations, the addition of Al has increased the panel cracking of a steel ingot, forming a line of AlN particles (Fig.*A*). They seem to have been precipitated at the grain boundary of the austenite during cooling after solidification.

The AlN particles shown in Fig.*A* were obtained from a 50 kg steel ingot by the carbon extraction replica. Figure *B* is a magnification of a part of Fig.*A* showing the fine, rectangular AlN particles precipitated continuously along the grain boundary. In a high-temperature tension test the line of AlN precipitates made the ductility of the steel lower and the impact value lower at lower temperatures. Desai† and Biggs‡ report that the formation of a brittle AlN phase seems to cause the ingot to crack. Presumably this phase is the line of AlN precipitates shown in the figures.

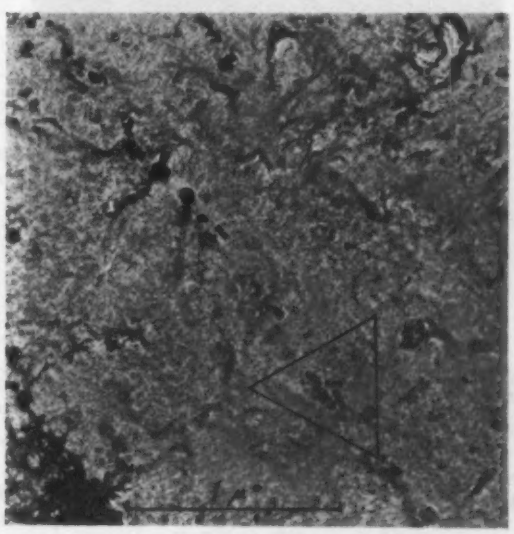
* B. C. WOODFINE and A. G. QUARRELL: *JISI*, 1960, **195**, 409–414.

† S. C. DESAI: *JISI*, 1959, **191**, 250–256.

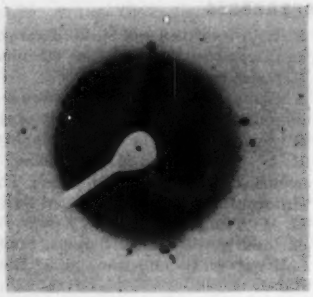
‡ B. L. BIGGS: *ibid.*, 1959, **192**, 361–377.



A AlN *precipitates extracted from the medium carbon steel, containing* 0·049% *acid-soluble* Al *and* 0·024%N, *which was sampled from the 50-kg ingot as a casting and heated at high temperature for a short time to change pearlite into martensite. The fine* AlN *precipitates are lined*

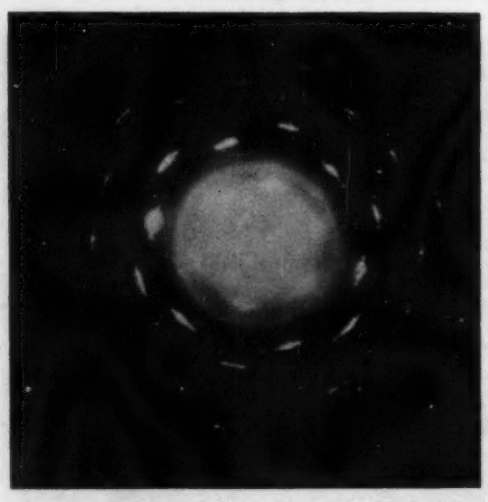


B *The same precipitates as shown in Fig.A observed at higher magnification*



C *Electron diffraction pattern*

D *Carbon extraction replica showing plate-shaped* AlN *particles* ×3500



E *Electron diffraction pattern of precipitate observed in Fig. D*

TABLE 1

Plate-shaped precipitate d value	hkl	Dendritic shaped precipitate d value	hkl	AlN X-ray powder data file d value	ASTM hkl
2·69	100	2·84	100	2·70	100
				2·49	002
2·40	101	2·52	101	2·37	101
1·87	102			1·83	102
1·57	110	1·64	110	1·56	110
				1·41	103
1·36	200	1·43	200	1·35	200
1·32	112	1·38	112	1·32	112
				1·30	201
		1·26	202	1·19	202
				1·05	203
1·02	210	1·07	210	1·02	210
				0·99	211
				0·93	105
				0·87	213

AUTHORS' REPLY

Dr **B. Woodfine** and Professor **A. G. Quarrell** (Department of Metallurgy, University of Sheffield) wrote: We were interested to learn that Mr Hasabe shares our views on the embrittlement of cast steel caused by AlN and to see his electron micrographs showing a line of AlN particles along an austenite grain boundary. It is unfortunate that the methods of specimen and replica preparation are not given, though it appears that the replica was taken from an etched microsection.

The work on intergranular fracture in our paper was undertaken some years ago. More recently Mr J. A. Wright and one of us (A.G.Q.) have been extending the investigation in the University of Sheffield and some of the results obtained are very relevant to Mr Hasabe's contribution. Electron micrographs and electron diffraction patterns have been obtained from carbon extraction replicas of fracture surfaces. A carbon film of suitable thickness was evaporated in the usual way on a freshly fractured surface and the metal was then etched through the film with a freshly prepared solution of 5% bromine in alcohol for about 30 s. The carbon replica was removed by immersing the specimen in distilled water.

A vacuum-melted steel containing 0·27%C and 1·54%Mn, to which additions of 6 lb/t Al were made immediately the boil finished, was cast into a metal mould under 20 cm pressure of nitrogen to give a final content of 0·020%N. A section cut from the columnar region of the ingot was (*a*) annealed at 900°C for 3 h and water quenched, and (*b*) tempered at 650°C for 1 h and water quenched. In this condition the steel gave a completely intergranular fracture and the replica contained the plate-like precipitate particles shown in Fig.*D*. The corresponding electron diffraction pattern is shown in Fig.*E* and the measured d-values in Table 1 where they are compared with the data for AlN given in the ASTM X-ray powder data file. The general agreement is good, though as would be expected from Fig.*E* some diffractions are missing owing to the highly preferred orientation of the precipitate plates.

Aluminium nitride in a dendritic form has also been observed in steels made in this way but the spacings are about 5% larger, suggesting that some element, possibly carbon, is in solid solution. We have observed both forms of AlN, both separately and together, in a number of casts, and we regard them as characteristic of steels containing Al and N which are subject to intergranular fracture.

The nitrides isolated by Mr Hasabe seem very similar to the plate-like form of AlN that we have observed, but which we have not been able to detect when we have applied the carbon replica technique to electropolished sections, even when the fractured surface has contained much of the plate-like AlN. We wonder if Mr Hasabe has given his sections a prolonged etch to free his AlN platelets from the boundaries so that they are able to fall on to the adjacent matrix.

NEWS

Announcements and News of Science and Industry

THE IRON AND STEEL INSTITUTE

Additional Honorary Members of Council

Sir Robert Shone, C.B.E. (Executive Member of the Iron and Steel Board) has been elected an additional Honorary Member of Council, in place of Dr L. F. C. Northcott, whose period of office has come to an end.

Publication of the Journal

Will members please note that the date of publication of the *Journal* is the 15th of the month.

Autumn General Meeting 1961

The Institute's Autumn General Meeting and a meeting of the Iron and Steel Engineers Group will be held in London from **Wednesday 29 November** to **Friday 1 December 1961.** Papers for discussion will include 'The future of ironmaking in the blast-furnace' and 'Energy balance in iron and steelworks' as well as papers on physical metallurgy. Full details will be published later in the *Journal*.

Institute Meetings, 1962

Annual General Meeting 2 and 3 May

Autumn General Meeting 28 and 29 November

Special Meeting in Germany By invitation of The Verein deutscher Eisenhüttenleute the Institute will hold a special meeting in Germany in June 1962. Further details will be published as soon as possible.

Members honoured by AISI

Sir Charles Goodeve, O.B.E., D.SC., F.R.S., and Mr W. F. Cartwright, President and Past-President respectively of the Institute, and Mr C. R. Wheeler, C.B.E., and Mr R. F. Summers, President and Past-President respectively of the British Iron and Steel Federation, were guests of the American Iron and Steel Institute at the 69th General Meeting in New York recently. Honorary Membership of the AISI was conferred upon Sir Charles Goodeve, Mr Cartwright, and Mr Summers at the dinner at the Waldorf-Astoria Hotel on 25 May; Mr Wheeler became an Honorary Member at the same function in 1959.

NEWS OF MEMBERS

Mr **R. Dingwall** has been appointed a special director of Dorman Long (Steel) and of Dorman Long and Co.

Mr **W. V. Golding** has been appointed a special director of Dorman Long (Steel) and of Dorman Long and Co.

Mr **S. Martin** has relinquished his post as managing director of the Staveley Iron and Chemical Company.

Mr **E. M. Marvill** has been appointed a director of the Staveley Iron and Chemical Company.

Mr **E. T. Sara** has been appointed assistant general sales manager of The United Steel Companies Ltd.

Note: In the footnote to the paper entitled 'Reconstitution of the light section mill at Round Oak Steel Works', by W. S. Walker, J. F. Whitfield, and G. A. V. Russell, page 126 of the June issue of the *Journal*, it was implied that Mr Whitfield is no longer with Round Oak Steel Works Ltd. Mr Whitfield is in fact chief engineer to the company and has occupied this position since 1954. A short note on his career was given under 'Contributors to the Journal' on page 182 of the June issue.

Obituary

Professor **John Harold Andrew** (*Hon. Vice-President, Bessemer Medallist*) (*elected* 1911), of Llandudno, Caernarvon, on 5 May 1961.

James Cecil Carr, C.B.E. (*elected* 1954), of Aylesbury, Buckinghamshire, on 15 April 1961.

D. L. Deshpande (*elected* 1957), of Bihar, India, on 5 April 1961.

Professor **John Meyes Lessells** (*elected* 1916) of Massachusetts, USA, on 17 May 1961.

Edwin Llyn Raworth (*elected* 1941), of Sheffield, on 18 February 1961.

Laurence William Malmgren (*elected* 1947), of Sydney, Australia, on 16 January 1961.

Thomas Edward Shaw (*elected* 1948), of Scunthorpe, Lincolnshire, in February 1961.

Steel Company of Wales

The Steel Company of Wales have announced that Sir Julian Pode (*Hon. Treasurer*), managing director, has been appointed to the additional office of deputy chairman and is to become chairman when Mr Harald Peake (*Member*) is released from that office after the annual meeting on 5 February 1962. From 6 February 1962 Mr W. F. Cartwright (*Past President*), assistant managing director and general manager of the steel division, is to be managing director; Mr David J. Young (*Member*), financial director and secretary, is to be assistant managing director; Mr R. W. Evans (*Hon. Member of Council*), director and deputy general manager of the steel division, is to be director and general manager of the steel division; Mr R. P. Tovey (*Member*), chief accountant, is to be secretary and chief accountant.

AFFILIATED LOCAL SOCIETIES

Liverpool Metallurgical Society

At the annual general meeting of the Liverpool Metallurgical Society for 1961 the following officers and committee were elected for the session 1961–62: *President* F. R. Brace; *Senior Vice-President* R. C. Jewell; *Retiring President* B. Ryan; *Hon. Secretary* J. F. Giblin; *Hon. Treasurer* B. Todd; *Members of Committee* W. F. Almond, C. Bodsworth, G. T. Callis, R. J. Morton, N. D. Shepherd, W. B. Taylor; *Hon. Vice-Presidents* R. S. Brown, H. Edwards V. L. Farthing, S. J. Kennett, W. Rose, J.P.

North Wales Metallurgical Society

During the annual general meeting of the North Wales Metallurgical Society for 1961, the results of the election of officers and of members of committee for 1961–62 were announced as follows: *Chairman:* S. McLintock; *Vice-Chairman:* H. H. Johnson; *Treasurer:* M. Hall; *Auditor:* L. S. Taylor; *Hon. Secretary:* S. Weir; *Asst. Secretary:* E. D. Harry; *Press Secretary:* H. M. Newbery; *Committee:* R. Davis, R. Farmer, H. B. Freeman, R. Mayorcas, G. Millington, R. Rippon, I. O. V. Thomas, and E. J. Williams.

The Society's proposed programme for the session 1961–62 includes the following:

26 Sept.	The oxygen steelmaking process *Emrys Davies*
11 Oct.	The blast-furnaces (*To be arranged*)
8 Nov.	Recent research on steelworks refractories *Dr J. White*
13 Dec.	Radioisotopes in metallurgy *Dr D. H. Houseman*
10 Jan.	The electron microscope (*To be arranged*)
14 Feb.	Photographic techniques in industry *J. Underwood*

THE INSTITUTION OF METALLURGISTS

Course on purer metals

The Institution of Metallurgists has announced the final programme of its refresher course on 'Purer metals' which is to be held in the Grand Hotel, Llandudno, on 27 and 28 October 1961. Titles and lecturers are as follows:

Engineering use of purer metals *Dr I. Jenkins*

Principles employed in producing very pure metals *Dr J. C. Chaston*

Technological advances in the production of purer metals *Mr G. T. Harris*

Properties of pure metals *Dr G. A. Geach*

At the end of the course it is hoped to announce the subjects for the 1962 course.

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Symposium on graphite-moderated reactors

In collaboration with the British Nuclear Energy Conference, The Institute of Physics and The Physical Society is sponsoring a symposium on 'The physics of graphite-moderated reactors' to be held in Bournemouth on 4–6 April 1962. Some papers for the provisional programme, which includes a visit to the Atomic Energy Establishment at Winfrith, Dorset, have already been promised; further contributions will be considered by the committee. The symposium is intended primarily for less senior members of research and development staffs working in this field. First preference to attend will be given to members of constituent bodies of the British Nuclear Energy Conference. Enquiries should be addressed to the Secretary, The Institute of Physics and The Physical Society, 47 Belgrave Square, London SW1.

THE DROP FORGING RESEARCH ASSOCIATION

Elections

At the annual general meeting of the Drop Forging Research Association for 1961, Mr R. Bennett was re-elected to the Council, and the following new Councillors were elected: Mr H. G. Brown, Mr W. E. A. Redfearn, Mr D. B. Russell, and Mr J. Shakespeare. At a subsequent Council meeting Mr J. H. Swain was elected chairman in succession to Mr W. E. Golcher, and Mr R. K. Johnson and Mr A. L. Stuart Todd were co-opted to the Council.

EDUCATION

CIBA Fellowship Trust: awards

The advisory panel of the CIBA Fellowship Trust has awarded fellowships for post-doctorial study to the following:

Mr R. F. C. Claridge (University of Auckland and Cambridge University) for study in radiochemistry at Cologne University

Dr J. S. Littler (Oxford University) for study in chemistry at the E.T.H. Zürich

Mr H. Stern (Oxford University) for study in theoretical physics at Brussels University

Mr F. I. B. Williams (McGill University and Oxford University) for study in solid state physics at Liège University.

Courses

Applied pneumatics

Courses intended to provide designers and users of pneumatic equipment with an understanding of the applications of compressed air equipment in industry are to be held several times a year, the first beginning in the early autumn. Full details and syllabus may be obtained from the Director, *Journal of Applied Pneumatics*, Parkshot, Richmond, Surrey.

New engineering general course

A course to be introduced into technical colleges during the autumn has been prepared by the Standing Committee of Technical Bodies in consultation with the engineering professional institutions. The course, which is intended for boys of about 16 years of age who have shown promise of being able to qualify as technicians, will require about 240 hours a year, and provides a common introduction to courses in both mechanical and electrical engineering; successful students will go on to either an ONC course or to a course for engineering technicians. The curriculum in each year of the course comprises: engineering science, mathematics, workshop processes and materials, engineering drawing, English and general studies; the individual syllabuses in each of these subjects have been fully outlined in Administrative Memorandum no.10/61 of the Ministry of Education.

Sandwich courses: enquiry

The National Advisory Council on Education for Industry and Commerce, whose chairman is Sir Harry Pilkington, has begun an enquiry into the organization of sandwich courses in technical colleges and colleges of further education. The aim is to increase efficiency in the use of staff, equipment, accommodation, and training facilities. The 'end-on' system whereby two quite separate groups of students follow the same course but use the college alternately (while one group is in college the other is in industry) will be among the methods of organization considered.

Any organization or person wishing to submit evidence to the sub-committee set up for this purpose should write to the Secretary, National Advisory Council on Education for Industry and Commerce, Ministry of Education, Curzon Street, London W1.

van Diest Gold Medal

The Colorado School of Mines, Golden, Colorado, USA, has awarded the van Diest Gold Medal for 1961 to Dr Albert W. Musgrave, computer designer and geophysicist.

CONTRIBUTORS TO THE JOURNAL

G. E. Davies, B.SC.—Senior scientific officer, ironmaking division, BISRA.

George E. Davies was born in 1923 and educated at King's College, Taunton. After military service he obtained a degree in geology from the University of London. He joined the BISRA ironmaking division as a geologist in 1953 and has been engaged primarily on problems concerning iron ores, including their concentration and preparation for the blast-furnace. In 1954 he was one of the UK members of Technical Mission no.228 which, under the auspices of OEEC, visited the USA and Canada to study the latest methods of ore beneficiation and concentration. He was elected an associate member of the Institution of Mining and Metallurgy in 1959.

G. W. Thomas, B.A.—Manager, operational research department (steel division), The Steel Company of Wales Ltd.

G. W. Thomas was born in 1925 at Cardiff, and educated at Canton High School, Cardiff, and University of South Wales, Cardiff, where he took an Honours degree in economics in 1950. Having taken a short course in Engineering at Queen's University, Belfast, in 1943, he was later commissioned into the Royal Engineers and served in the Far East. He spent two years as a management trainee with Marks and Spencer Ltd before joining The Steel Company of Wales as a quality control statistician in the operational research department in 1953. Before his present appointment in March 1958, he served as assistant manager of the Cornelly Quarry, technical assistant to Mr W. F. Cartwright, and assistant manager of the operational research department.

F. Cooke, B.SC., A.R.I.C.—Senior research chemist, Central Research Laboratories, Richard Thomas and Baldwins Ltd, Aylesbury.

Frederick Cooke was born in Sheffield in 1919 and educated at the Firth Park Grammar School, Sheffield. During employment in the period 1935–1939 as a laboratory assistant in the Department of Fuel Technology, University of Sheffield, and as a chemist with Colliery Engineering Ltd, he continued to study at the Central Commercial College, Sheffield, for an external degree. After war service in H.M. Forces, he entered the University of Sheffield, and graduated in 1950. He joined the steelmaking division of BISRA as a scientific officer after graduation and remained there until joining his present company in 1954, where he is concerned principally with the study of gases in metals and with the corrosion and other chemical aspects of protective coatings on steel.

NEWS OF SCIENCE AND INDUSTRY

Obituary: Mr W. H. Apthorpe

The death occurred in Surrey on 17 March of Mr W. H. Apthorpe, Deputy Chairman and former Managing Director of the Cambridge Instrument Co. Ltd. He was 75.

During his service with the company for more than 50 years he was particularly interested in electrocardiographic equipment, and in the field of automatic temperature control, he pioneered the development of the Apthorpe Regulator, one of the earliest forms of control to use a pivoted galvanometer.

DSIR Research Council: new chairman

Lord Hailsham, Minister of Science, has appointed Sir Harold Roxbee Cox as chairman of the Council for Scientific and Industrial Research for five years from 1 October 1961. The chairman-elect is an engineer by profession and during more than 20 years of government service he did pioneer work on jet propulsion, gas turbines, and fuel and power problems. In 1954, after six years as Chief Scientist of the Ministry of Fuel and Power, he began to work in industry and became chairman of the Metal Box Co. Ltd in early 1961.

ERA annual report

The 40th annual report of the Electrical Research Association for the year ended 31 December 1960 contains the Association's Report of Council for the year and the Director's Report on Researches which summarizes briefly and clearly developments in over 15 fields of research: it is illustrated. There is also a list of over 100 reports on research, which were issued during 1960: those available to non-members of the Association are indicated.

Cold rolling at Brinsworth

United Steel's new Brinsworth cold strip mill at Steel, Peech and Tozer has gone into production after satisfactory trial runs. A four-stand, four-high tandem mill takes pickled strip from the adjacent hot mill, and with ingenious automatic gauge control, on stands 1 and 4, and inter-stand tension control between stands 3 and 4, it produces cold strip of consistently high quality and dimensional accuracy.

Refinements include full mechanical control for feeding and stripping the coils. The mill motors are powered from rectifier/inverter units which feed back to the supply during deceleration, so that the mill is in effect running most economically at full speed.

Two 290-ft long Nassheur furnaces, each with a capacity of 5 tons/h, anneal the coils which are single-stacked on trays and under a protective atmosphere throughout.

The final stages of tempering on a two-high temper mill and slitting to a required width, are fully mechanized. Quality is checked in a testing laboratory on the site, and comprehensive records of all material rolled are maintained. The mill can handle all qualities of steel from 0·010 to 0·016-in gauge range in up to 18-in widths, although the main demand at present will be for low-carbon steels, tempered from hard bright unannealed to dead soft, as well as intermediate tempers in the annealed condition.

New nickel alloy

The International Nickel Company (Mond) Ltd have developed a new 18%Ni alloy which they claim is the only known material that can achieve a yield strength above 250 000 lb/in^2 and yet retain nil ductility temperature below −80°F. Its notched tensile strength is above 400 000 lb/in^2, measured under severe test conditions with a notch radius of 0·0005in. Strength is developed without loss of ductility and toughness through a heat-treatment involving age hardening of martensite: 'maraging'. With proper finishing temperature off the mill, the treatment is to hold about 3 h and air cool. Solution annealing at 1 500°F before ageing is optional. No quenching is needed; full properties are developed in heavy sections without distortion. The alloy steel's nominal composition is 18%Ni, 7%Co, 5%Mo, and below 0·5%Ti, with maximum 0·05%C. Modification of the basic composition produces higher and lower tensile strength: strength levels up to 500 000 lb/in^2 are possible. A 10-ton commercial heat was produced in an arc furnace by air melting and ingots as large as 23×42in rolled into plate on conventional equipment. Low work-hardening tendencies permit extensive cold-forming and shaping. Machining characteristics are excellent both as rolled and fully hardened. It can be welded manually or automatically. Sound welds are achieved without pre-heating. Post-weld ageing further improves the quality.

A patent application covering the steel has been filed with the US Patent Office.

New plant and equipment

AEI-Birlec Ltd have produced a new furnace, needing no muffle, which in its prototype form is designed for the continuous bright annealing of strip.

Wild-Barfield Electric Furnaces Ltd have produced additions to their range of hf generators: the new sets have continuous outputs to BS.1799 of 18, 27, 36, and 45 kW. The makers

state that no extra floor space is needed and that reliability has improved while maintenance has been simplified. The three sets with lower outputs can be converted to higher output on the user's premises. The valve guarantee has been extended to 6000 h.

Millom Hematite Ore and Iron Co. Ltd have installed a new blast-furnace which is mechanically charged under automatic control and can be charged by one man. The design and erection was carried out by *Wilfred Marley Ltd*. The cost of the furnace was about £500000 The company also announce an achievement by one of their old furnaces, an eight-year-old blast-furnace which during one campaign has produced more than 1 million tons of high-grade hematite pig iron. The furnace is of 14-ft hearth dia., and was blown in during April 1953.

British Furnaces Ltd have recently received orders for gas carburizing equipment from Albion Motors Ltd who require for their Scotstoun works four sealed quench furnaces with automatic sequence control, dew-point controlled RX endothermic atmosphere generating plant, and ancillary equipment.

Sharon Steel Corporation are to employ the Kaldo steelmaking process in a new plant to be built at their Roemer works in Farrell, Pa. When completed in 1962 it will have two converters and a designed initial capacity of about 1 m. tons a year. The corporation is believed to be the first US company to use the process.

Johnson Matthey and Co. Ltd have developed a Ni–Si–Cu alloy, Mallory 53, which they state has mechanical qualities equal to those of phosphor bronze or brass but much greater electrical conductivity. Designers of electrical equipment, particularly those involved in the production of miniaturized components, may be interested in the company's data sheet 1300:332 which gives details of the alloy, and is available from their head office at 73–83 Hatton Garden, London EC1.

Company news

Associated Bearing Co. Ltd is a new company formed in India: the main shareholders are SKF Gothenburg, The Investment Corporation of India Ltd (which is in the TATA group), and Skefko Ball Bearing Co. Ltd. Manufacture is planned to start towards the end of 1962.

Ipsen Industries Ltd, a new company whose address is 53 Victoria Road, Surbiton, Surrey, has been formed by Ipsen Industries Inc., of Rockford, Illinois, and Ipsen Industries International GmbH, of Kleve, West Germany, to facilitate sales and service in the UK of their products: atmosphere and vacuum automatic heat-treatment equipment.

GEC Ltd and *Richardsons, Westgarth and Co. Ltd* have decided to pool their resources for the design, development, sale, and manufacture of heavy electricity generating and industrial power plant.

International Computers and Tabulators Ltd and *National Data Processing Corporation* of Dallas, Texas, USA, have made an agreement in connexion with the marketing and manufacture of their products whereby their complementary products will expand each company's range.

Consett Iron Company are to install new steelmaking plant using the Kaldo and LD processes by the end of 1961, and a continuous strip and bar mill by the end of 1962. The new plate mill which was opened in April is part of the same £30 m. development plan.

Schloemann AG have been awarded a contract by the Broken Hill Pty Ltd, Newcastle, Australia, for the manufacture of a 39-in blooming and slabbing mill; ingots up to 6 tons and slabs up to 10 tons will be rolled and annual capacity is planned as 1750000 tons.

Incandescent Heat Co. Ltd have installed a gas-fired radiant tube heated lift-off annealing furnace for Lancashire and Corby Steel Manufacturing Co. Ltd. The furnaces have an output of 1 ton/h and are similar to some supplied to the SOMESIA steelworks in Argentina and the single-stack furnaces being built for the new Spencer Works of Richard Thomas and Baldwins.

International Computers and Tabulators Ltd have added more manufacturing space to their Croydon factory.

Simon-Carves Ltd have been awarded a contract by the Eastern Gas Board to supply and erect an Otto continuous reforming plant at Dunstable works to produce 5 m. ft³/d of towns gas from liquefied petroleum gases: the order includes the supply of shift conversion plant for deoxification, and feedstock storage and handling facilities.

Contract news

Brightside Foundry and Engineering Co. Ltd have received orders worth more than £300000 from Wolverhampton and Birchley Rolling Mills Ltd for the rolling mill and its equipment associated with the new 14-in merchant bar and section mill which is to be installed at the company's Wolverhampton works. The company is a member of the Thomas W. Ward group and the steelwork department of the parent company will erect the buildings to accommodate the mill; John Smith (Keighley) Ltd, another member of the group, will supply and install five new overhead cranes. The scheme will take about 2½ years to complete and will increase productive capacity to about 150000 tons of bars and sections a year. The total cost will be over £500000.

Honeywell Controls Ltd have received an order from the Continuous Casting Co. Ltd for the instrumentation of a twin-strand continuous casting machine to be installed at the Abbey Works of the Steel Company of Wales. The machine will be instrumented by a new integrated two-wire electric system known as the ElektriK Tel-O-Set, a system introduced earlier this year by Honeywell and for which they have already received a £300000 order for the 720-mile Northern India pipeline project. Provision is made for the later addition of a data handling unit. The contract is worth about £15000.

Davy and United Instruments Ltd have signed a contract worth over £90000 with Stankoimport of Moscow for the supply of eight transmission gamma-ray thickness gauges to be installed in Russian steel mills; the gauges use a radioactive isotope as a measuring medium.

FORTHCOMING CONFERENCES

Conference on engineering inspection and non-destructive testing

A national conference, planned at the request of the Joint Committee of Materials and their Testing and The British National Committee for Non-Destructive Testing, will be held at Oxford in September 1961. The aim of the conference, which is being organized jointly by the Institution of Engineering Inspection and the Society of Non-Destructive Examination, will be to discuss the function of management in relation to inspection, the economics of inspection and non-destructive testing, and the recruitment and training of inspection staffs. Residential accommodation over the period 5–8 September has been reserved at Queen's College and New College, Oxford. The total cost of the conference including fee, accommodation, and all meals in College will be £9 10*s*. Further information may be obtained from: The Oxford Conference Secretariat, The Institution of Engineering Inspection, 616 Grand Buildings, Trafalgar Square, London WC2.

Welding in shipbuilding: joint symposium

The joint symposium on welding in shipbuilding, sponsored by the Institute of Welding, the Royal Institution of Naval Architects, the North East Coast Institution of Engineers and Shipbuilders, and the Institution of Engineers and Shipbuilders in Scotland, will be held in London during October and November 1961. Contributions to the symposium have been promised from many countries; papers will cover many aspects of the topic, including design of welded hulls, construction, materials handling, welding of alloys, non-destructive testing of welds, and training of ship welders.

Second ILMAC in 1962

Following the sucess of the first ILMAC (International congress and exhibition of laboratory, measurement, and automation techniques in chemistry) which took place in November 1959 in Basle, the organizing committee decided unanimously to repeat the event. The second ILMAC will be held from 15 to 20 October 1962, again in the buildings of the Swiss Industries Fair in Basle.

GIFA again in Dusseldorf in 1962

The date for the second GIFA (International Foundry Trades' Fair) to be held again in Düsseldorf, has been fixed for 1–9 September 1962.

GIFA is a specialized fair for foundrymen and makers and users of castings. The range of exhibits will chiefly comprise foundry machines and equipment, raw materials, auxiliary materials, and requisites. As in 1956, when the first GIFA was held and met with considerable success, the VDG (German Foundrymen's Association) will hold its annual meeting during the fair.

INDUSTRIAL PUBLICATIONS RECEIVED

A handsome brochure in red and black describes the graphite electrodes, anodes, and nuclear specialities distributed by *Great Lakes Carbon International Ltd* of London.

Eutectrode 66, a new low-hydrogen, high-tensile electrode is the subject of a leaflet from Eutectic Welding Alloys Co. Ltd.

Fork lift industrial contract hire, a leaflet, describes the truck hire and maintenance service of George Cohen and Co. Ltd.

Bulletin LH203-D gives details of an improved gas scrubber, a high-velocity scrubber, combined units, and typical applications of Peabody Ltd products.

Wiggin Nickel Alloys no.59 contains articles on the 4-ft wind tunnel at the Wharton works of English Aviation Ltd, and the properties of a new casting alloy developed for high-temperature service.

Publication B.40 of Deloro Stellite describes their new powder weld process employing a torch for hardfacing with 'Stellite'; the torch consists of an adaptor added to the Schori 50.

Information sheet no.10 of Bailey Meters and Controls Ltd describes and illustrates schematically a fuel oil flow instrument the firm installed for Taylor Bros. Ltd.

Visco Dust Collection describes the range of dust collectors produced by the Visco Engineering Co. Ltd, including cyclone dust collectors, the Visco-Beth automatic collector, and combined fume removal and dust recovery plant.

The Australian Ferrous Forging Industry describes the history, structure, market, labour, and materials of the ferrous forging industry in Australia.

Die steels details the products of Hadfields Ltd in this field.

Machining Wiggin high-nickel alloys describes general practice in machining nickel-based alloys; it recommends general principles, and considers the particular aspects, e.g. turning, milling, and the best accepted practice in each case.

UMK Cobalt is an elegant survey of the field of cobalt, with special reference to the Union Minière du Haut-Katanga Société Générale Métallurgiques de Hoboken, who have produced the brochure. There are many illustrations, some in colour.

McKee Head Wrightson is a booklet that illustrates briefly the scope and scale of the company of that name.

Microsan describes the equipment that forms the Cambridge Instrument Company's X-ray analyser.

'Refractory suspended construction' and 'Incanite—the special process cast iron' are two leaflets from the *Incandescent Heat Company Ltd.*

The latest instrument and filter catalogue from *The Gelman Instrument Company* is entitled 'Dust topics'.

Thos. W. Ward Ltd of Sheffield recently issued the sixth edition of their catalogue 'Rails and rail accessories'.

The Thompson project is a brochure explaining the efforts and achievement of The International Nickel Company of Canada, Ltd, at Thompson in Manitoba, from late 1956 when it was announced that newly discovered ore bodies were to be developed until April of this year when the $185 000 project was formally opened. The airborne exploration for nickel-containing bodies is among the preparatory work described.

A guide to arc welding electrodes is a booklet prepared by the arc welding section of BEAMA. The booklet, which costs 5*s*., covers the field comprehensively; specifications, approval tests, regulations, and standards are outlined, and various types of electrodes with manufacturers are listed.

Data sheets on steel castings are issued by the Steel Castings Development Committee. Prepared from data provided by BSCRA, they aim to provide data to supplement those given in British Standards. Sheets 1 to 5 are now available from BSFA.

The cold-heat process for submerged induction hardening is described by Delapena in a leaflet.

Fine steels provides information in tabular form of billets, bars, slabs, and forgings produced by Hadfields for automobile and engineering purposes.

Melting furnaces are the subject of a leaflet from Monometer Manufacturing Co. Ltd.

Super Permo electrical iron is described in a leaflet from Samuel Osborn and Co. Ltd.

Large transformers (*DB5/6*) and *Silicon and germanium rectifiers* (*R193/2*) are illustrated brochures from Hackbridge and Hewitt Electric Co. Ltd.

SS News no.20 from Solus-Schall Ltd is devoted to non-destructive and material testing.

Hy-contact tower packings is a leaflet issued by Hydronyl Ltd.

Head Wrightson give details of the Series One cooling tower in a leaflet.

BISRA summary 161 deals with the identification of corrosion products by X-ray methods.

CHANGE OF ADDRESS

The Consolidated Zinc Corporation Ltd have moved to 6 St James's Square, London SW1, although their registered and transfer offices remain at 9 Basinghall Street, London EC2.

DIARY

21 June – 5 July INTERNATIONAL TRADE FAIR—Trieste, Italy.

5–15 July BUILDING AND PUBLIC WORKS EXHIBITION — Belle Vue, Manchester.

6–12 July INSTITUTION OF ELECTRONICS—Annual exhibition—College of Science and Technology, Sackville Street, Manchester 1.

7–29 July SOVIET EXHIBITION—Earls Court, London.

10–14 July ELECTRON MICROSCOPY GROUP—Annual Conference—University of Nottingham.

14 July ELECTRON MICROSCOPY GROUP—Symposium '*Physics of sectioning and the embedding process*'—University of Nottingham.

23–29 July ROYAL INSTITUTION OF NAVAL ARCHITECTS—Summer School for teachers of naval architecture—College of Aeronautics, Cranfield.

BRITISH IRON AND STEEL INDUSTRY TRANSLATION SERVICE

The following translations are now available, in addition to those given on page 184 of the June 1961 issue of the *Journal*. When ordering please quote the number in bold type.

The development of economical high temperature creep-resistant austenitic steels in Czechoslovakia. (From Czech.) PODOŠIL, F., *Hutn. Listy* (Prague), 1959, *14*, (12), pp.1121–1124. (£5 10*s*. 0*d*.) **[1675**

The influence of the mode of combination of an element on its determination by emissive spectrographic analysis. (From German.) DICKENS, P., and BAHR, A., *Arch. Eisenhütt.*, 1960, *31*, March, pp.135–143. (£6) **[1806**

Effect of drawing temperature when drawing steel wire. I. (From Japanese.) NISHIOKA, T., *Nippon Kinzoku*, 1958, *22*, (5), 225–229. (£3) **[1848**

Technical problems in the construction of power supply systems in integrated iron and steelworks. (From German.) ENGELHARDT, H., *Stahl Eisen*, 1960, *80*, July 21, 1000–1006. (£4 15*s*. 0*d*.) **[1852**

Development of economical furnaces for the magnetic roasting beneficiation of ores. (From Russian.) KARMAZIN, V. I., *Stal'*, 1955, Aug., pp.692–698. (£4 5*s*. 0*d*.) **[1871**

Gas leakage tests on casing joints under conditions closely resembling those met on site. (From German.) HAUK, V., *Erdöl Zeitschrift*, 1959, (12), pp.498–504. (£4 15*s*. 0*d*.) **[1875**

The thermal-shock behaviour of steels and high temperature materials. (From German.) EICHHORN, F., *Stahl Eisen*, 1960, *80*, Sept. 15, pp.1275–1283. (£5 5*s*. 0*d*.) **[1953**

Investigation of iron ores by means of differential thermal analysis. (From German.) SCHENCK, H. *et al.*, *Arch. Eisenhütt.*, 1960, *31*, Aug., pp.451–458. (£4 15*s*. 0*d*.) **[1959**

Creep behaviour and stress relaxation of cold worked steel wires with different pretreatment. (From German.) PFÜTZENREUTER, A., *Stahl Eisen*, 1960, *80*, Sept. 29, pp.1321–1336. (£9 15*s*. 0*d*.) **[1965**

A modern continuous pickling process (spray pickling). (From German.) ANON, *Draht*, 1960, *11*, Feb., pp.59–60. (£1 10*s*. 0*d*.) **[1979**

Use of radioisotopes in metallurgy and metal physics (with bibliog.—317 refs.) (From German.) KULIKOV, I. S., (KULIKOW I. S), *Neue Hütte*, 1960, *5*, June, pp.348–354; July, pp.420–425. (£7 5*s*. 0*d*.) **[1991**

Force- and torque-measuring devices for rolling mills. (From German.) DIETRICH, T., *Stahl Eisen*, 1960, *80*, March 17, pp.372–374. (£3) **[1995**

Utilization of waste heat, and combination of gas turbines and steam power plants, in the iron and steel industry. (From German.) PFENNINGER, H., *Stahl Eisen*, 1960, *80*, Oct. 27, pp.1540–1549. (£5 15*s*. 0*d*.) **[2012**

A new method for the analysis of carbides in steels. (From Czech.) BRHÁČEK, B. *et al.*, *Hutn. Listy*, (Prague), 1960, *15*, (9), pp.679–686. (£6 15*s*. 0*d*.) **[2017**

Chromatography applied to the continuous control of industrial plants. I. Analyses of a C_1 to C_4 hydrocarbon mixture. (From Italian.) RIO, A. *et al.*, *Chim. e Ind.*, (Milan), 1959, *41*, Dec., pp.1185–1188. (£2 15*s*. 0*d*.) **[2023**

Present position of large-capacity arc furnaces in steelworks. (From French.) BOUTIGNY, R., and BARBAZANGES, C., *Rev. Mét.*, 1960, *57*, July, pp.589–600. (£5) **[2024**

Deoxidation of iron by melting under vacuum. (From French.) TUBILLON, P., *Rev. Mét. Mém. Sci.*, 1960, *57*, Sept., pp.649–657. (£3 5*s*. 0*d*.) **[2040**

Studies of the quench-ageing of mild steels from various methods of production. (From German.) NACKEN, M., and HELLER, W., *Arch. Eisenhütt.*, 1960, *31*, Jan., pp.39–46. (£5 5*s*. 0*d*.) **[2053**

The evaluation of testing methods for non-metallic inclusions in carbon steel—Ck 22. (From German.) ECKSTEIN, H.-J., and SCHNEIDER, K., *Neue Hütte.*, 1960, *5*, Oct., pp.607–617. (£6) **[2057**

Determination of gases in metals by the hot extraction process using gas chromatography. (From German.) LESSER, R., and GRUBER, H., *Z. Metallk.*, 1960, *51*, Sept., pp.495–501. (£3 15*s*. 0*d*.) **[2059**

The recovery of chromium from slags obtained when melting stainless steel scrap in the arc furnace using oxygen. (From Czech.) CHOVJKA, J., *Hutnick* (Prague), 1960, *10*, (1), pp.2–5. (£3 5*s*. 0*d*.) **[2063**

Rapid automatic analysis by X-ray fluorescence of ore powders and solutions from hydrometallurgical works in the Union Minière du Haut Katanga. (From French.) HANS, A., *Chim. Anal.* (Paris), 1960, May, pp.236–244; June, pp.282–286. (£6 5*d*. 0*d*.) **[2073**

The rapid determination of iron in basic Bessemer slags by X-ray fluorescence in steelworks. (From French.) HARVENG, I. *et al.*, *Rev. Mét.*, 1960, *57*, May, pp.423–436. (£6 10*s*. 0*d*.) **[2074**

Aerodynamics of open-hearth furnace flames. (From Russian.) MITKALINNY, V. I., and NI XUE ZI, (*Nauch. Dok. Vys. Shkoly. Met.*, 1959, (1), pp.73–79. (£4 5*s*. 0*d*.) **[2077**

Investigation of gas movement in a restricted area. (From Russian.) GLINKOV, M. A., and CHOI EN SIR, *Izvest. VUZ Chern. Met.* (Stalinsk), 1960, (2), pp.163–168. (£3) **[2078**

The effect of return sinter during downdraft sintering of iron ores. (From German.) RAUSCH, H., and CAPPEL, F., *Stahl Eisen*, 1961, *81*, Jan. 19, pp.96–102. (£5 5*s*. 0*d*.) **[2090**

A new method for the determination of metallic, bivalent, and trivalent iron-bearing materials. (From French.) STOLL, N., and WAGNER, A., *Rev. Univ. Mines* (Liège), 1960, (10), Oct., pp.436–443. (£3 15*s*. 0*d*.) **[2098**

A study of the slagging process in refractory bricks. (From German.) KONOPICKY, K., and ROUTSCHKA, G., *Deutsche Keram. Ges.*, 1961, Jan., pp.1–8. (£4 10*s*. 0*d*.) **[2110**

The embrittlement of steel by absorption of atomic hydrogen. (From German.) WERNER, O., *VDIZ*, 1959, *101*, Oct. 1, pp.1303–1304. (£2) **[2135**

A new technology in the melting of ball-bearing steel ShKh15 using white foaming slags (From Russian.) CHUIKO, N. M. *et al.*, *Izvest. VUZ Chern. Met.* (Stalinsk), 1960, Aug., pp.38–47. (£4 15*s*. 0*d*.) **[2136**

Malcomizing: a process for hardening stainless steels. (From Italian.) ANON, *Macchine*, 1958, *13*, Dec., pp.1197–1199. (£1) **[2140**

Preparation of iron single crystals by zone melting. (From German.) HILLMANN, H., and MAGER, A., *Z. Metallk.*, 1960, *51*, Nov., pp.663–666. (£3) **[2146**

Deoxidation problems in modern steelmaking. (From German.) PLÖCKINGER, E., *Radex Rund.*, 1961, Jan., pp.485–491. (£2 15*s*.) **[2164**

ABSTRACTS OF CURRENT LITERATURE AND BOOK NOTICES

Iron and Steel Manufacture and Related Subjects

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* Abstracts, the reference to which is marked with an asterisk, are or are to be made available as translations.

ABSTRACTS

These abstracts are also available on index cards in advance of publication in the *Journal*, each abstract being classified under the Universal Decimal system (UDC). Details and subscription notes can be obtained from the Secretary, The Iron and Steel Institute.

MINERAL RESOURCES

Magnetites and the mining industry P. G. Kihlstedt (*Tek. Tidskr.*, 1960, **90**, Sept. 9, 821–831) Swedish magnetites, their concentration, structure, use of the Mörtsell separator, and metallurgical applications are discussed.

Rajhara iron ore mining (*Iron Steel Rev.*, 1960, **4**, Dec., 45–46) This mine, owned by the Bhilai steelworks, is estimated to contain some 114×10^6 t (65–69%Fe). Mechanization equipment has been supplied from the USSR and it is intended to supply 7000 t daily to the steelworks which require 2×10^6 t ore per annum. A sinter plant is being erected.—C.V.

New Zealand ironsands K. Shaw (*Iron Steel*, 1961, **34**, Feb., 48) The exceedingly large tonnage on the beaches of the West Coast has long been known and it is likely that they may now be developed and an iron and steel industry established. Some 11 sites are tabulated representing some 2370×10^6 t with a 5–42%Fe content. However six of these may be too difficult to exploit or too remote from deep water. Of the remaining five ($\sim 311 \times 10^6$ t) four have Fe values of 20–42%. Lake Taharoa (263×10^6 t, 42%Fe) is considered the most promising; the smelting process to be used has not been decided. A high Ti content is present requiring a special furnace technique. Japan and Sweden are said to be the only countries using this sand for smelting and the former is very interested in the question of importation.—C.V.

Quebec Cartier's iron ore development J. Grindrod (*Min. J.*, 1960, **255**, Dec. 9, 656–658) Plans for development of a low-grade deposit are given.

Nickel deposits in the Quill Creek and White River areas, Yukon F. A. Campbell (*Can. Min. Met. Bull.*, 1960, **53**, Dec., 953–959).

ORES—MINING AND TREATMENT

What changes does future hold for iron ore industry? R. M. Lloyd (*Iron Age*, 1960, **186**, Dec. 15, 114–116) A study of world ore reserves, growing consumption, and imports versus exports, and their effect on US economy and the world position generally, with the rise of potential new areas of supply with limited steel markets, is presented and discussed, in the light of mining costs, transportation costs, and artificial trade restrictions; and a trend towards concentration in large operations is predicted.—S.H.-S.

Studies on the minor elements in pyrites from the Chichibu Mine, Saitama Prefecture. (1, Arsenic) K. Takimoto, T. Minato, and S. Hirono (*Suiyokwai-Shi*, 1960, **14**, Aug., 118–121) As commonly occurs as a main component of arsenopyrite and as a secondary component of gersdorffite, tetrahedrite, enargite, etc., in sulphide deposits, but it is sometimes contained in pyrites as a minor constituent. In this paper the As content in pyrites taken from the Chichibu mine was quantitatively analysed by means of a fluorescent X-ray spectrograph, and then the relationship between a manner of distribution in the pyrites and its geological conditions of formation was examined.

Reagents in pyrite flotation T. Zadkin and R. Doig *J. S. Afr. Inst. Min. Met.*, 1960, **61**, Dec., 284–289) Thiocarbanilide and mercaptobenzthiazole were tested. Cresylic acid as frother and substitution of Na isopropylxanthate by MBT was successful.

Beneficiation of ferruginous sandstones of the Northampton sand ironstone formation G. E. Davies (*JISI*, 1961, **198**, July, 282–289) [This issue].

New ore handling facilities at Amsterdam (*Met. Bull.*, 1960, Dec. 9, supplement, i) With illustrations.

Origin and history of the ore carrier. Developments since 1903 J. M. Murray (*Iron Coal Trades Rev.*, 1960, **181**, Oct. 14, 841–842) An extract of a section of a paper by the chief ship surveyor of *Lloyd's Register of Shipping* on 'Merchant Ships, 1860–1960', surveying in condensed form the history of bulk ore carriers in the Great Lakes and in Sweden from the beginning of the 20th century, down to current examples of straight ore carriers and oil/ore carriers.—S.H.-S.

New system is pelletizing iron ore Cleveland-Cliffs Iron Co. (*Steel*, 1960, **147**, Oct. 10, 160, 163) The advantages of the travelling grate and the rotary kiln are combined for agglomerating and pelletizing iron ore concentrate and the system is being investigated as a normal step in preparing iron ore. A plant recently installed and in operation is described.—S.H.-S.

Production of high-metal content pellets from finely ground concentrates V. Ya. Miller, L. I. Leont'ev, and V. A. Utkov (*Stal'*, 1961, (2), 102–105) Lisakova limonite wet metallic concentrates with coke fines gave strong Conditions, composition and temp. effects were pellets with much metallic iron on heating studied. At 1220–1250°C free iron reached 58–60%, equivalent to reduction to metal of 78–80% of the total Fe content. The fuel used is cheap and great reductions in fuel required in the blast-furnace were achieved.

Production of fluxed briquettes for the metallurgical industry V. P. Onoprienko, A. E. Lebedev, and D. M. Furman (*Stal'*, 1961, (2), 97–102) A process using a roller press was developed for treatment of finely ground concentrates; the plant produces 1·6 t/h with 9 rmp and a pressure of 200 kg/cm²; further increases in pressure have no effect on volume but increase green strength. Heating at 550°C was optimum. A flow-sheet for an industrial installation is given. It is claimed that briquettes are superior to sinter.

Magnetic roasting of iron ores in a travelling grate roaster H. H. Wade and N. F. Schulz (*Min. Eng.*, 1960, **12**, Nov., 1161–1165) An experimental roaster built by the University of Minnesota and trials on low-grade ores are described. The process appears to be technically and economically feasible.

One-half century of sintering E. W. Shallock (*Blast Furn. Steel Plant*, 1961, **49**, Feb., 145–147, 158) A review. The prospect of still larger sintering machines is considered.

New sinter plant starts up R. B. Christmas (*BHP Rev.*, 1960, **37**, Oct., 9–11) The production of this second sinter unit varies with the type of ore used. The figures for the earlier machine are given in parentheses: width 13 ft 1½in (8 ft 3½in), suction area 1894 sq. ft (1076 sq. ft), production rates 255 (145), and 155 (88) t/day, this being for fast sintering ore and ore requiring longer time to agglomerate respectively. The sintering process is briefly described and the use of limestone and pyrites additives are discussed.—C.V.

Sinter brings down coke consumption Workington Iron and Steel Co. (*Engineering*, 1960, **190**, Dec. 23, 870) The 'FOCUS' project (Foreign ore concentrates usage) at Workington is briefly reviewed; the ore as a powdered concentrate being shipped from Kirkenes. Details as to the plant and equipment and handling capacity are given.—C.V.

Influence of air flow, coke content and moisture content on the temperature distribution of the sintering bed (Fundamental study of sintering of iron ores—1) K. Sanbongi, N. Nishida, and A. Suzawa (*Tetsu to Hagane*, 1960, **46**, Nov., 1527–1532) Studies on Goa haematite and Larap magnetite in a small sintering pan are reported. The effects of air flow, coke content, and moisture were evaluated.

Increased capacity of belt conveyors in a sinter plant D. S. Volkov (*Stal'*, 1961, (1), 20) The running of belts at higher speeds is recommended.

Reducibility of sinters at different Soviet works K. K. Shkodin (*Stal'*, 1961, (1), 5–11) Apparatus for measuring reducibility by a countercurrent process was elaborated and continuous determination of CO_2 is recommended as a guide to the reduction process. The method is compared with others and much data is tabulated showing results with various sinters.

Microhardness of Korch sinter N. A. Vasyutinskii (*Stal'*, 1961, (2), 105–106) There is a tendency for sinter gradually to crumble in storage. This is apparently caused by internal stresses arising from the large variety of components forming micro-regions. An amorphous cement seems to be formed by rapid cooling and this is highly strained. This is the case in fluxed and in unfluxed sinters alike. Diamond tester imprints were used and the impressions tended to go out of shape either at once or after a short delay, tending to a circular form.

Iron ore reduction studied with grate-kiln system T. G. Kirkland (*Steel*, 1960, **147**, Dec. 19, 114–117) A reduction kiln and its operation are described in production of high purity, metallic iron pellets, as feed to hot-blast cupola, electric arc furnace, or other melting facility.—S.H.-S.

The importance of pore diffusion in the reduction of iron ore L. von Bogdandy and W. Janke (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58, paper 8; reprint from *Zeits für Elektrochemie*, 1957, **61**, (9), 1146–1153) Measurement of the reduction velocity of porous, nodular Fe_2O_3 showed that in the temp. range 600–800°C the total reaction rate is determined by the velocity of the gas diffusion in the pores from the reaction front into the open air, in other words the absolute amount of pores or the porosity is not rate-determining, but the labyrinth factor of gas diffusion is (25 refs).—T.G.

Magnetizing reduction in a recuperative rotary furnace S. Eketorp (*Iron Coal Trades Rev.*, 1960, **181**, Oct. 21, 905–907) Extracts from a paper describing a recuperative rotary furnace for the magnetic roasting of hematite ore (now re-named 'magnetic reduction' in distinction from an oxidizing process) with a description of the operation of a pilot plant furnace now being tested in Domnarvet are presented and results are reported.—S.H.-S.

FUEL—PREPARATION, PROPERTIES AND USES

Fuel economy in the iron and steel industry (*Iron Coal Trades Rev.*, 1960, **181**, Sept. 9, 573–574) Progress during the last 40 years is reviewed.—C.V.

Coal petrology and coal rank—observations in relation to carbonization G. W. Fenton and A. H. V. Smith (*Year Book Coke Oven Man. Assoc.*, 1960, 337–364) A brief summary of modern coal petrology is given and certain definitions are clarified (maceral, lithotypes, etc.), and examples are given from the Barnsley and Silkstone seams. The petrographic constituents of coal are discussed in relation to Notts and Derby, Yorkshire, Lancashire, Durham, and South Wales. Test oven (600 lb) experiments have been made on vitrinite-rich base coals at three different levels of rank with various proportions of exinite- and inertinite-rich additives, in carbonization; the variables have been kept as constant as possible and the findings are presented in a series of tables, but the statistical examination of the results is not yet completed. The most marked effect of maceral composition is the influence on the strength of the coke as measured by shatter and micum tests. This and related findings are discussed. It is considered that the optimum use of durainous coals in the production of hard cokes might well be the first limited objective in present-day petrographic research.

Studies in blending coals for the production of metallurgical coke J. Bandopadhyay, T. C. Tarafder, N. N. Das Gupta, and A. Lahiri (*J. Inst. Fuel*, 1960, **33**, Dec., 592–597) The following conditions must be fulfilled: (a) max. fluidity from the Giesseler plastometer test should not be <15 dial div/min, (b) the plastic temp. range from this test $\leqslant 25°$; (c) rate of semi-coke formation in this plastometer at a constant temp. of 420° should be 0·15 min^{-1}, and (d) volatile matter on air dried basic $\geqslant 32\%$. The first two conditions limit the max. and the remaining two the min. usable percentage of low-volatile coal. From these upper and lower limits of the two individual coals in binary blends, the proportion of the two giving the optimum results can be deduced but this is subject to the %-ash ($\geqslant 20\%$) since excessive mineral matter is undesirable. Graphs relating to various coals are given to illustrate the argument (15 refs).—C.V.

Coal preparation with particular reference to carbonization coals: Problems connected with fine coal and high moisture D. A. Hall and H. MacPherson (*Year Book Coke Oven Man. Assoc.*, 1960, 195–215) On account of mining and preparation changes, the moisture content in carbonization smalls has been steadily increasing resulting in handling difficulties and loss of oven throughput. An optimum moisture content of 8% was accepted but it is now considered that 4–6% is more reasonable. If $<4\%$ dust troubles and increase in coking time would result while $>6\%$ there is loss of throughput due to increased carbonization time, the heat being partially used in evaporating the water, lower bulk densities of charge, variation in coke quality, increased NH_4-liquor, and concomitantly greater effluent problems. The observations are based on the work being carried out in Durham.

Improvement of coking coal quality R. M. von Storch (*Reg. Tech. Meet. AISI*, 1958, 375–380) The high volatile coal deposits of Utah have only marginal coking quality and to improve the metallurgical characteristics they are blended with low and medium volatile coals from Colorado, Oklahoma, and Arkansas. A further improvement resulted from a blending of the highly volatile coals, followed by washing before the final blending. The system of discharging, blending, and conveying the 5in × 0 coal is briefly described. The blended coal is removed from the ultimate storage bins by vibrating feeders; these ensure a continuous supply to the cleaning system; water is added and the coal–water passes over four screens which split the feed into two sizes (5in × ¾in and ¾in × 0). The latter, plus most of the water, flows by gravity to the fine coal sump while the 5in × ¾ coal is collected and transferred to the Chance Cone. The working of this, the disposal of the refuse, and the conservation of the water which is pumped back to the plant for re-use, is summarized. The fine coal, previously separated from the coarse before cleaning, plus the silt removed from the coarse circuit, are collected in a fine coal sump and pumped to the top of the plant into two bowl desilters which are described. The slime is piped to the refuse slump while the deslimed, de-watered product is mixed with clean water and flows to the Deister tables and from these to the solid bowl centrifugal filters for dewatering. The cleaned coal is weighed, automatically sampled, and mixed before delivery to the railroad. At peak operation a 76 t coal truck can be filled every 8 min.—C.V.

The future of the coking industry D. T. Barritt and V. Robinson (*Coke Gas*, 1960, **22**, Dec., 522–525) A review of the paper delivered to the Coke Oven Managers' Assoc., Inst. Gas Eng. and BCRA.

A pilot plant for high temperature carbonization of coals N. N. Dasgupta, K. Y. Shrikhande and V. V. Rao (*Year Book Coke Oven Man. Assoc.*, 1960, 438–446) The pilot plant, instrumentation, and operation are described, the conditions of carbonization, yield, and physical properties of the coke in three experiments being recorded. The three ovens used have capacities of 980, 1100, and 1180 kg of coal per charge.—C.V.

Mobile shed reduces cost of coke oven rebuilding Bethlehem Steel Co. (*Steel*, 1960, **147**, Oct. 3, 78) A unit, permitting piecemeal overhaul of the multi-oven batteries, protecting workmen and work in progress, and its method of operation, are described.—S.H.-S.

Modern coke-oven practice K. G. Beck (*Stahl Eisen*, 1961, **81**, Feb. 2, 195–199) The changes that have taken place in coke-oven practice during the last 30 years or so are reviewed. Modern coke-oven practice is characterized by an ever-increasing application of automatic controls.—T.G.

Water treatment for steam plant and cooling systems in the coke oven industry J. T. Aynsley (*Year Book Coke Oven Man. Assoc.*, 1960, 365–383) Scale formation, corrosion, caustic cracking, foaming, and priming are briefly summarized and methods of water treatment are examined and compared with a view to choice of treatment. Corrosion in the feed water due to O_2 is relatively small at pressures below 200 psig provided the water is distinctly alkaline: at higher pressures, trace quantities can have serious effects, the max. permissible residual—O at 650 psig being 0·01 ml/l. The use of hydrazine is considered. Treatment of steam and condensate cooling systems, and control of scale formation and corrosion are summarized. In the discussion the mechanism of the hydrazine, reaction the cost of water treatments, and the disposal of sludge, are further dealt with.

Review of new specifications on the sampling of coal and coke R. C. Tomlinson (*J. Inst. Fuel*, 1960, **33**, Oct., 476–478) A short account is given of the new BS.1017: 1960, with observations on the importance of regard for sampling principles as the foundation for scientific analysis and chemical and instrumental techniques.—S.H.-S.

Production of metallurgical fuel from brown coal G. L. Kennedy (*J. Inst. Fuel*, 1960, **33**, Dec., 598–608) A review relating to recent work in Australia with 27 references. The early German work, the Lurgi, Lurgi-Krupp, and developments up to 1953, was followed and is discussed in some detail. Attention was then turned to the development of carbonization technique to obtain a better char from the industrial briquettes; if heating rate during drying and low-temp. carbonization was kept low, cracking of the briquettes was almost eliminated and the drop shatter strength of the char was greatly increased. The ideal heating curve now used is characterized by a very slow temp. rise during low-temp. carbonization followed by a fast temp. rise during high-temp. carbonization. Indirect heating is unsatisfactory in drying and low-temp. carbonization but either direct or indirect heating can be employed during the high-temp. carbonization but with direct heating the max. is 850°. The lack of fused structure and the highly reactive nature of the char have led to the conclusion that hard char would not be suitable for blast-furnace or cupola fuel unless the reactivity is reduced; the use of char in cold blast cupolas has not borne out these predictions and has suggested further research to reassess the role of the fuel in the combustion processes in a shaft furnace. The slow reactivity of coke to O_2 is as much a limitation of furnace performance as high reactivity of char and the more mature view is advanced that this is a property to be taken advantage of in removing the present limitation of the specific output of shaft furnaces.

These hints may help you select gas cleaning system Joy Manfg. Corp. (*Steel*, 1960, **147**, Nov. 7, 122–123) Cleaning systems in metallurgical applications, including centrifugal collectors, bag filters, wet collectors, and electrostatic precipitators, with the types of problems to which they are severally applicable, are discussed, with brief descriptive data.

Automatic control systems for gas mixing stations J. K. Sazavsky (*Iron Steel Eng.*, 1961, **38**, Jan., 117–124) A review. Three layouts are given: (a) available natural gas, propane, and air; (b) coke-oven and blast-furnace gas with a mixture of natural gas and air; (c) a triple gas-mixing station supplying an entire steel mill with three qualities of mixed gas, air, coke-oven, blast-furnace, and natural gas giving

common gas, preferred gas, and lean gas. In this circuit the position of the calculator, calorimixers, the controllers, and actuators, and flow, pressure, and density transmitters are indicated.—C.V.

Obtaining gas from low-grade coal North Thames Gas Board (*Smokeless air*, 1960, (115), Autumn, 60) This new process is being tested in a pilot plant to be built by the North Thames Gas Board and is expected to produce about 2 million ft³ blue water gas per day. Powdered coal, air (or O_2), and steam are forced into a bed of molten slag which produces blue water gas continuously. This process differs slightly from that operated in Germany with brown coal; the modifications are discussed. It is claimed that there is complete combustion and no by-products, except slag, result.

The purification of coke oven gas in tower purifiers J. V. Burgess and J. Codman (*Year Book Coke Oven Man. Assoc.*, 1960, 447–461, discussion 461–468).

System of waste heat utilization in metallurgy using heat pumps V. A. Spiridonov and L. I. Slobodyanyuk (*Stal'*, 1961, (1), 87–91) Heat recovery from coke oven discharge, slag, and waste gases is considered using the low-pressure steam produced. Problems of the H_2S contained are referred to, but the concentration is much smaller than is generally supposed.

AIR POLLUTION

Control of dust W. B. Parkes (*Ironfounding Health and Safety*, 1960, 39–46) The standards employed in South Wales, in France, and by the International Labour Organization at Geneva are examined and a plea for one standard is made. The methods of collecting and measuring the dust are discussed. It is implied by both the French and Geneva recommendations that silica is the only dangerous constituent in the dust and this is reviewed in relation to other industries outside the foundry. The reduction in airborne dust is examined at some length.—C.V.

Air pollution control research L. Silverman and C. E. Billings (*Reg. Tech. Meet. AISI*, 1958, 511–549) Agglomerator studies are reported; it has been found that the screw agglomerator can act as a heat transfer unit and with an inlet temp. of 1000°F there was a drop of 200–250° giving a value of 4–8 BTU/h/ft² as compared with unity for a straight pipe. To improve on this a 6in jacketed unit is being investigated. Slag wool fibres were chosen as filters as they were cheap, readily available, and can function to 1000°F. This is used in a deep bed 1–2in thick and packed to 3–5 lb/ft³ packing density giving 97% voids. It differs from other filtration techniques as velocity is maintained at 100–150 ft/min which drastically reduces space. On OH fume the filter gives consistently 95·99% efficiency if mechanical leakage is eliminated. It has been shown that the fibres can be washed and reused 8–10 times; 4 t/day would be required for an average 250 t furnace. The work on pilot plants is summarized. The use of short-wave *in situ* cleaning of filter is considered. Agglomeration studies suggest that filter life may be extended by particle agglomeration.—C.V.

Dust control in industry J. Bigwood and Son Ltd (*Iron Steel*, 1961, **34**, Feb., 52–55) The Traughber dry wet filter installation at the sinter plant at Workington is described. This gives an average efficiency of 97·3% which when coupled with the preliminary cyclone figure of 93·2% gives an overall figure of 99·8%. The recovered dust is returned to the process in a dry state. The results of various tests are given.—C.V.

Measuring the dust content of industrial gases and of the air-measurements of dust on the ground K. Guthmann (*BCIRA J.*, 1960, **8**, Nov., 883–902; from *Stahl Eisen*, 1959, Aug. 6 1129–1141) This is BISITS translation 1440.

Recommendations on heights for new industrial chimneys G. Nonhebel (*J. Inst. Fuel*, 1960, **33**, Oct., 479–513; *Smokeless Air*, 1960, **31**, Autumn, 46–53) A paper, with two appendices, followed by a discussion. Considerations arising from the powers granted Local Authorities under the Clean Air Act are reviewed and recommendations are made supported by formulae, with stress on the dual importance of discharge at ground level plus the rate of dust deposit rather than ground-level concentration of SO_2. In the discussion comparison between London and California smog was drawn by Dr Metcalfe and the effect of chimney height on poplar growth at Kew was cited.—S.H.-S.

TEMPERATURE MEASUREMENT AND CONTROL

The metal-clad thermocouple J. A. Stevenson (*Brit. Steel*, 1960, **26**, Nov., 392–393) A description of the construction and applications of metal sheathed, mineral insulated flexible thermocouple assemblies, developed by Johnson, Matthey and Co. Ltd. Advantages include flexibility, resistance to corrosive atmospheres, and fast response.

Temperature measurement in furnaces E. E. Sjöstrand (*Tek. Tidsk.*, 1960, **90**, Aug. 12, 735–740) Types of thermocouples and radiation pyrometers and their applications are reviewed.

REFRACTORY MATERIALS

New trends in refractories D. Yerouchalmi (*Silicates Indust.*, 1960, **25**, Dec., 551–557) The development of industrial refractories, and modern uses and trends are surveyed. Special reference is made to metallurgical applications by the Consett Iron Co. Ltd.—P.F.

How to choose the right refractories F. H. Fanning (*Mod. Castings*, 1960, **38**, Nov., 42–43) The proper selection of process in conjunction with refractory is discussed.

Recent improvement of basic refractories T. Ikenoue (*Imono*, 1960, **32**, May, 377–384) A description of the advantages and disadvantages of basic cupolas, and how detailed care and slag control allows the basic process to be economic.

Casting large sections of basic refractories H. M. Kraner, R. C. Padfield, and R. E. Hauser (*Amer. Ceram. Soc. Bull.*, 1960, **39**, Sept., 456–459) It is proposed to cast the bottom as a monolithic structure. Rammed compositions are compared with brick but each have their limitations. Gunniting is reviewed; this employs more water than ramming, and would not appear to be suitable for OH bottoms; it may however be suitable for some applications where max. density is not required. Some high-magnesia compositions used for ramming can be employed for casting; only 6½–7¼% water is required and consolidation by use of concrete vibrators deep in the mass is effective in the elimination of entrained air and giving good compaction. Densities of 175 lb/ft³ are normal. The design and other aspects are discussed.—C.V.

Basic considerations on the use of refractory materials. Part 3—Application L. D. Castells (*Acero Energ.*, 1960, **17**, July–Aug., 58–64, 67–68, 70) Conditions under which refractories are used are considered, and the properties and applications of several types of refractory are enumerated.

Quality and uses of Belgian blast-furnace slag cements L. Blondiau (*Silicates Indust.*, 1960, **25**, Dec., 545–550) Belgian Standard Specifications relating to cements are reviewed in connexion with quality assessments of blast-furnace cements. The properties of Belgian blast-furnace slag cements are shown to equal those of Portland cement.—P.F.

IRON AND STEEL, GENERAL

Steel: Avant Garde C. M. Parker (*Weld. J.*, 1960, **39**, Dec., 513s–519s) A talk presented at 1960 American Welding Soc. National Fall Meetings, reviewing the present condition and future prospects, and especially the part being played and to be played by Russia, in the International Steel situation, as affecting the future of the United States.—S.H.-S.

Developments in the iron and steel industry during 1960 I. E. Madsen (*Iron Steel Eng.*, 1961, **38**, Jan., 127–179) A very detailed survey of the progress made in the USA. A partial list of expansion plans of indicated companies is tabulated (cost, ingot capacity, steelmaking facilities, iron capacity, ore preparation, hot and cold mills, finishing facilities, heating furnaces, and pits, etc.), and expansion in other countries is also summarized. Blast-furnaces and coke plants, steelmaking, rolling mill, and finishing developments are also discussed, the mechanical aspects and handling of materials being covered. A special section deals with electrical progress, instrumentation, automatic control, computers, rectifiers, generators, and X-ray emission gauges, etc., while a list of electric motor drives (140) of 300 hp and over is provided, details being given.—C.V.

The Italian steel industry G. Grenier (*Mines Mét.*, 1961, No.3547, Jan., 17–20) A brief historical review of the Italian steel industry from 1860 to the present day, with some data on resources and equipment, is presented.

Poland's steel industry—plans and progress F. Kaim, A. Chojkowski, and T. Migda (*Brit. Steel*, 1960, **26**, Nov., 389–390, 393; from *Prz. Techn.*, 1960, **18**) The 1961–65 five-year plan is discussed, with some data on new plant, and the manufacture of special steel plate and tubing. The account is extracted from three articles.

A steel plant to be built in Turkey (*Blast Furn. Steel Plant*, 1961, **49**, Feb., 171–172, 176) This integrated steel plant is to be built on the Black Sea coast at Eregli at a cost of 245×10^6 and the initial plant output is estimated at 470000 t/year ingots with expansion to 10^6 t. A general description is given together with a list of the suppliers of the plant and equipment.—C.V.

Iron and steel in India. III. The future pattern of steelmaking G. R. Bashforth (*Brit. Steel*, 1959, **25**, Dec., 426–429) A general survey of present and projected output and installations.

Observations of the steel industry in India and Japan J. L. Young (*Iron Steel Eng.*, 1961, **38**, Jan., 61–66) An illustrated survey with statistics.—C.V.

China's iron and steel plants. 9. Shanghai (*Met. Bull.*, 1960, Dec. 20, supplement, i, iv) A brief description of works built or projected.

Towards new successes for ferrous metallurgy V. Andreev (*Stal'*, 1961, (1), 1–4) An editorial. Recent achievements and future prospects are discussed.

Automation in iron and steel (*Times Rev. Ind.*, 1960, **14**, Dec., 21) Non-technical notes.

BLAST-FURNACE PRACTICE AND PRODUCTION OF PIG IRON

Rebuilding a blast-furnace at Newcastle (*BHP Rev.*, 1960, **37**, Oct. 2, 16–17) A pictorial presentation of the progress. The work was completed between January and April.—C.V.

300 t/day blast-furnace for Osaka Steel Manufacturing Co. Ltd (*Ishikawajima Engng. Rev.*, 1960, **17**, July, 185–191; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1960, **7**, Nov., 431) [No abstract].—C.F.C.

Installation of Tobata 1500 t/day blast-furnace and accessory equipment (*Ishikawajima Engng. Rev.*, 1960, **17**, July, 215–220; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1960, **7**, Nov., 431) [No abstract].—C.F.C.

Blast-furnace campaigns extended with castables Harbison-Walker Refractories Co. (*Steel*, 1960, **147**, Nov. 7, 114) The use of castable refractory materials, in the maintenance and repair of worn blast-furnace linings, is briefly discussed with examples.—S.H.-S.

Gunning blast-furnace lining Harbison-Walker Refractories Co. (*Iron Coal Trades Rev.*, 1961, **182**, Jan. 27, 187–188) A report of experience in the USA. A cutaway drawing of a blast-furnace shows the types of monolithic lining materials recommended for the specific areas. A description of the maintenance work involved is given in relation to one furnace requiring 267·5 t castable refractory, the whole job being completed in 117 h gunning time. The obvious advantages are the saving of serviceable brickwork and the speed with which the furnace can be got back on line. This process extends the furnace life for two, three, or even more years.—C.V.

Hard surfacing of blast-furnace bells and hoppers F. J. Gaydos and N. Fragasso (*Weld. J.*, 1961, **40**, Jan, 18–24) Materials, equipment, and methods employed in the submerged-arc process, using iron and nickel-base alloys, now being operated at Gary Steel Works,

Gary, Indiana, which was devised to control an urgent wear problem, are presented with data and illustrations.—S.H.-S.

Carbon cooled by air slows blast-furnace hearth wear E. M. Summers (*Steel*, 1960, **147**, Nov. 14, 123) Air-cooled carbon hearths to prevent penetration of the firebrick pad and the furnace foundation by molten iron are reported, and briefly described.—S.H.-S.

The automatic stockhouse J. F. Meissner (*Iron Steel Eng.*, 1961, **38**, Jan., 99–106) It has been said that the automatic stockhouse is a long step down the road to uniform iron quality. This automation of blast-furnace operations is discussed and consists of complete automatic charging of the blast-furnaces, accurate composition of the charges, and weight determination of the materials comprising the charge, rapidity of carrying out these operations, and accurate and complete read-out and accumulation of all data which can be obtained almost immediately. An interesting full discussion on the various facets of this project is appended.—C.V.

Effect of ore beneficiation on blast-furnace operation J. D. Saussaman (*Reg. Tech. Meet. AISI*, 1958, 355–373) Blending, screening, concentrating, ore sizing, agglomerating, and the use of self-fluxing sinter are discussed. It is pointed out that there is no ready-made pattern to fit every furnace and that in every case the raw material must be appraised and the appropriate steps taken. Initially, ore dressing, sizing, etc., were carried out inside the blast-furnace but it is now realized that it is more economical and more satisfactory to carry out these steps outside the furnace, leaving the furnace to carry out the process for which it was intended, the smelting of iron ore

Controlling measurements of blast-furnace masonry using cobalt isotope ^{60}Co M. Pertot (*Nova. Proizv.*, 1960, (3–4), 161–165) The choice and location of isotopes and the Geiger counter records used to follow wear on vertical and horizontal cross-sections are described.

Influence of the state of oxidation of the iron of a sinter on its treatment in the blast-furnace F. Peache (*Rev. Mét.*, 1960, **57**, Sept., 771–773) An analysis is presented of the results of four months operation of a blast-furnace on a charge consisting of 60% crude ore and 40% sinter (70% Lorraine ore fines and 30% flue dust). It was found that burden wt/day was increased by 100–200 kg when the degree of oxidation rose by 1%.

The effect of higher pressure of top gas on blast-furnace production E. Terlecki (*Hutnik*, 1960, **27**, (12), 463–466) To increase the output of a blast-furnace the burden should first be prepared so as to make it more easily reducible and anything that may interfere with the uniform flow should be removed as well. Then the amount of blast and its temp. is raised. As however the flow rate has its optimum the amount of gas can be increased by 10–15% by increased pressure at the top which results in decrease of flow of the top gas and better heat exchange between the gas and the burden.

Oxygen keeps steel in turmoil (*Chem. Eng.*, 1960, **67**, Nov. 28, 77–78) Recent pronouncements on use in the blast-furnace, with mention of the OH and converter, are noted. O_2 requirements are estimated.

Hydrocarbons in blast-furnaces (*Iron Coal Trades Rev.*, 1960, **181**, Oct. 21, 903) A brief report on the concept being developed by the Esso Research and Engineering Co., scientific affiliate of the Standard Oil Co. of New Jersey to the effect that heavy oil of high heat content can be successfully injected into the bottom of blast-furnaces with increased capacity and decreased costs of hot metal production.

Oil injection increases steel output Standard Vacuum Oil Co. (*Iron Steel Rev.*, 1960, **4**, Dec., 51) The injection of heavy oil hydrocarbons into the bottom of blast-furnaces so as to increase capacity and decrease cost is discussed; a similar application of natural gas is also indicated. The work is experimental and data obtained on a full-scale furnace are still necessary.—C.V.

Fuel injection increases blast-furnace iron output Pittsburgh Coke and Chemical Co. (*Steel*, 1960, **147**, Dec. 5, 112–116) A series of examples of combustible gas injection in blast-furnace operations and their effects are described.—S.H.-S.

Pneumatic-hydraulic control system for the distribution of the blast on blast-furnaces W. A. Jaenike (*VDIZ*, 1960, **102**, Dec. 1, 1683–1684) A control system, consisting of a main valve for controlling the blast in the main pipe system and chokes in front of each tuyere, for controlling the blast of blast-furnaces is described. Usually the system operates fully automatically, but it may also be controlled manually, as for instance during slipping. The advantages offered by this system include, *inter alia*, substantial easing of the working of the furnace when using a burden consisting of fines, and automatic freeing of any stopped tuyeres.—T.G.

Slag formation in the blast-furnace operating at high pressure B. N. Starshinov, V. D. Sinitskii, I. V. Kotel'nikov, and M. L. Lavrent'ev (*Stal'*, 1961, (1), 12–17) Melting of primary slag begins 3–4 m from the stockline where gas flow is greatest. Where ore is present in excess this occurs 10–12 m below the stockline. Reduced Fe and Mn ores and to a small extent dissociating limestone take part. S begins to separate from the coke in the 850–105°C zone. Changes in operation are suggested in view of these findings.

Blast-furnace stoves Z. Warczewski and J. Blachocinski (*Hutnik*, 1960, **27**, (12), 453–462) The authors point out that not enough attention is being paid to the construction of stoves and in consequence though they are working at relatively low temp. they have to be rebuilt every 3–5 years. Their capacities should be designed with regard to the output of the blast-furnaces. In particular the chequers should be standardized and modernized as well as the burners, the lining should be improved, and they should be insulated to prevent heat losses.

On the automatic control equipment of the hot stove for the 300/day blast-furnace at Osaka Steel Manufacturing Co. Ltd (*Ishikawajima Engng. Rev.*, 1960, **17**, July, 192–201; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1960, **7**, Nov., 431) [No abstract].—C.F.C.

Cowper stoves of refractory concrete blocks A. I. Borodulin and M. G. Levin (*Stal'*, 1961, (1), 17–19) Claims of reduced costs and better heat recovery and high blast temp. are made for stoves with concrete block linings. With mechanization, labour productivity is increased 15% and cost is reduced 35%. The blocks may weigh up to 5 t.

A new expression for slag basicity and its application to several iron and steelmaking reactions K. Mori (*Nippon Kinzoku*, 1960, **24**, (6), 383–386) A new expression in terms of mole fraction and empirical constants for the elements present is advanced and applied to MgO solubility, S capacity, desulphurizing reactions of blast-furnace slag, S partition reactions, and Ti and Si reduction in slags containing TiO_2. Also Si reduction from fluxes into weld metal.

Increase in output of an experimental blast furnace by addition of oxygen and carbon dioxide to the blast R. Spolders and W. Wenzel (*Stahl Eisen*, 1961, **81**, Feb. 2, 149–154) Substantial increases in output of a blast-furnace by enrichment of the blast are obtainable only if the gas distribution and gas permeability are kept at optimum values. With this proviso, up to 40% increase in output was achieved in an experimental blast-furnace of 0·6 m hearth diameter by enrichment of the blast to 16·6% CO_2 and 45% O_2. The trials are described in detail and the results presented in many graphs.—T.G.

Experiment with a 1-ton test blast-furnace. Chromium elimination, the use of Miike-coke, high-alumina ore and sinter containing Ti, injection of lime powder through tuyeres K. Kanamori, M. Tate, C. Nakane, T. Dezaki, S. Izumisawa, K. Choroo, K. Maeda, C. Hyonte, and A. Furuyama (*Rep. Inst. Ind. Sci., Tokyo*, 1960, **10**, Dec., pp.70) [In Japanese] Using enriched blast, cooling with fine ore, and removal of S by injection of lime, Fe–Mn, CaF_2, and Al directly into the bath were studied. Miike coal is high in S and this appears in the iron. Scaffolding is a more serious problem. High-Al_2O_3 slag was blown with powdered limestone suspensions and effects of high TiO_2 were also examined.

Wrecking blast-furnace linings Grant Lyon and Co. Ltd (*Iron Steel*, 1961, **34**, Feb., 42–44) A specialized service is described in detail and once the wrecking operation starts a 24-h day cycle is continued until the job is completed. It is pointed out that before a blast-furnace can be relined, it is necessary to remove the burden, the old lining, and the salamander, and that even the saving of a day can mean an extra 1000–1500 t of iron. The water required to flood down the furnace, the time factor for dismantling the top gear, bells, hopper, and the stripping of pipe work and cooling devices can all be assessed with accuracy together with the rebuilding time. The wrecking time however, can be indeterminate. With this systematized approach this can be assessed.—C.V.

Direct reduction of iron ores in rotary kilns S. Zielinski (*Hutnik*, 1960, **27**, (12), 466–472) A review of five methods of direct reduction of iron ores (R–N, Tanner, Scortecci, Brasset, and Stürzel processes), is given.

A contribution to the problem of producing pig iron in the future iron works at Skopje B. Marincek (*Nova Proizv.*, 1960, (1–2), 1–13) The author discusses the choice of the method best fitted for producing pig iron at Skopje. He considers, first of all, the raw material at hand, discusses the methods for producing pig iron already known and advances proposals for producing pig iron at Skopje.—C.F.C.

Purification of molten iron by the application of low-frequency vibration J. H. Gittus (*Iron Steel*, 1961, **34**, Feb., 64–67) It is shown that by vibrating a crucible of molten cast iron, many of the trace elements that inhibit spheroidal graphitization can be removed; this is favoured by oxidizing conditions. Removal of As and Sb is difficult and unfortunately Mg is removed but the effect is not so marked when small castings are vibrated as when a melt is vibrated in a hot crucible. With SG iron castings, it is possible to inoculate them by vibration provided that the Mg initially present in the melt is sufficient to compensate for the ensuing loss. The apparatus used in the experimentation is described and the results obtained are tabulated.—C.V.

Granulation of molten iron (*Engineering*, 1961, **191**, Jan. 20, 126) The pouring of molten metal directly into large reservoirs of cold water to give granulated pig iron has proved so successful that five further companies have adopted this method. The molten metal, tipped from the ladle by an overhead crane, flows along the runner and divides into two streams before dropping into jets of water; this produces globules of the size of a pigeon's egg (25% much smaller) and the iron in this form can be transported with a high degree of efficiency. The throughput of the latest plant at Liège is 4 t/min.—C.V.

The R-N direct iron process D. E. Babcock (*Reg. Tech. Meet. AISI*, 1958, 1–49) Eight commercial processes for the production of direct iron are listed with the conditions favouring their use and the chief characteristics. In the R-N process the ore is reduced in crushed form in a rotary kiln with a special air burner port arrangement allowing charge heating by burning air in combustible or reducing gases; also a fuel combustion chamber for partially burning the gases over the charge which flows counter current to the gases. With ¼in ore, the temp. of reduction is 1832–1877°F; the coarser fraction −+¼ reduced at 1922°F below fusion and clinkering point temp. The reducing agent was fine coke (size not specified) but anthracite or fine lignite could be used and a small amount of limestone was added to remove S. Unreacted excess coke was recovered for return to the kiln reduction cycle. Metallized ore was fround wet and magnetically separated to contain 80% total Fe, 60% metallic Fe. This process can be applied to ores varying from the lowest to the highest grade producing high grade melting stocks suitable for electric furnace or other melting operation. Both product composition and yield are controllable and the yield is almost quantitatively related to the percentage of metallization of the Fe contained in the ore. The kiln lining life is a sensitive measure of the performance. Mineville concentrates and Red Mountain ore and the briquetted iron products

derived from them by the R-N process are compared.

PROPERTIES, TREATMENT AND USE OF SLAGS

A critical review of viscosity of CaO–MgO–Al_2O_3–SiO_2 melts E. T. Turkdogan and P. M. Bills (*Ceram. Bull.*, 1960, **39,** Nov., 682–687) Blast-furnace slag systems are considered and the silica equivalence of alumina is related to composition. The variation of heat of activation for viscous flow with temp. is discussed.

Contribution to the problem of the granulation ability of cement raw flour G. Mussegnug (*Hüttenwerk Oberhausen Tech. Ber.*, 1955–58, paper 43; no source given, pp.5) Cement raw flour is a very fine powder, usually a mixture of a number of components, for making Portland cement. The selection of the raw materials with particular reference to granulation ability and the use of by-products from iron and steelworks is dealt with. It is recommended that crystallized slag be used for improving the granulation of the raw flour.—T.G.

DIRECT PROCESSES

Are new steelmaking processes coming? W. Dick (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58, paper 11; reprint from *Handelsblatt. Die technisch Linie*, 1957, Nov. 25, 4) An historical consideration discussing the aspects of new steelmaking processes such as the Rotor process. The requirements of an improvement in quality also determine the choice of new processes to keep abreast with future output requirements.—T.G.

Modern steelmaking processes, such as the Rotor process. Why? How? and For what? W. Dick (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58, paper 26; *Vorgetragen auf der Gemeinschafts-Veranstaltung* DVEh/VDI, 1957, July 5, pp.9) The author reviews the trend towards new steelmaking processes and discusses the pre-suppositions for the application of these processes. He describes the Rotor process in detail with special emphasis on the steel qualities obtainable.—T.G.

Ore to molten metal by direct reduction A. de Sy (*Mod. Castings*, 1960, **38,** Nov., 38–41) An electric direct reduction method is described, by means of which either liquid steel of the rimming type or a carbon-rich alloy of the pig iron type may be produced.

Direct reduction process provides own reaction heat A. Wimmer (*Steel*, 1960, **147,** Dec. 26, 66, from *Stahl Eisen*) A German process, using a mixture containing aluminium, silicon, and titanium, blended with ore and ignited, is described, the combustion heat helping to reduce iron oxides and producing mild steel.—S.H.-S.

The Rotor steelmaking process E. Spetzler (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58, paper 27; *Vorgetragen auf der Jahreshauptversammlung* 1957 *der Ges. Deutscher Berg- und Hüttenleute*, 1957, Nov. 14, Leipzig, pp.8) The author describes and discusses the rotary process of steelmaking; he deals in particular with: design and construction of the rotor, the metallurgy of the process, steelmaking practice, control, and instrumentation, heat balance, lining dust removal of the waste gases, and steel quality and economies.—T.G.

PRODUCTION OF STEEL

What's in the future for steel? (*Steel*, 1960, **147,** Nov. 14, 120–123) Suggestions from metallurgists and research men at the Philadelphia Metal Show, predicting more progress in high strength steels, better fabrication properties, more air-hardening tool steels, higher strength in stainless steel, increased use of vacuum equipment, and wider use of automatic controls, are among matters briefly summarized.—S.H.-S.

Steelmaking by new processes R. Graef (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58; paper 24; reprint from *Deutsche Zeitung und Wirkschaftszeitung, Eisenhüttentag*, 1958, (88), Nov. 5, pp.2) The author outlines briefly the refining of steel by the various new processes involving the use of oxygen. The advantage of the oxygen processes is that they can be adapted easily to almost any raw material.

Practical steel plant research K. L. Fetters (*Blast Furn. Steel Plant*, 1961, **49,** Feb., 164–170) A general survey. Numerous smaller topics are touched upon.—C.V.

Economizing scrap F. Bernat (*Hutnik*, 1960, **10,** (12), 480–482) Problems arising from the constantly increasing demand for scrap, and from the increase in the alloy content of steel scrap in recent years are discussed. Possible remedies are suggested.—P.F.

Changing attitude towards metal scrap E. P. Wood (*Engineering*, 1960, **190,** Oct. 21, 534–535) A general review. A special plea is made for further thought on the handling and sorting methods. Automobile scrap is specially mentioned; the treatment in the USA is indicated where after the body is taken off and the engine removed, the chassis is passed through an incinerator where all inflammable material is burnt, the remains being charged into giant baling presses which take two bodies at a time and reduce them dimensionally to steelworks requirements.—C.V.

The solution rate of various ferro-chromes in liquid steel and the behaviour of the chromium carbides during the solution process K. Blankenstein and E. Plöckinger (*Tech. Mitt. Krupp*, 1960, **18,** Nov. 37–43) The solution rate of various ferro-chromes was determined in the laboratory in stationary, quiescence steel baths. The solution rate depends on the carbon contents of the ferro-chrome and of the steel bath. High-C ferro-chromes showed a higher solution rate in a low-C steel bath than did low-C ferro-chromes, and vice versa. The structure of the iron–chromium solid solution precipitated during the solidification process is independent of the carbide phases introduced by ferro-chrome addition. The results of the study are presented in many graphs and tables.

Equilibrium constants of reactions in steel melts of the Fe–V–O system H. Sawamura (*Suiyokwai-Shi*, 1958, **13,** April, 382–386) Using the experimental data of Chipman and Dastur the equilibrium constants for the reactions $FeV_2O_{4(s)} = 2V + 4O + Fe(l)$ and $V_2O_{3(s)} = 2V + 3O$ are calculated by a different method.

Some recent developments in the use of oxygen in tonnage steelmaking D. Urane (*Castings*, 1960, **6,** Aug., 9, 11, 13, 15, 17, 19, 20) The LD process and duplexing with the hot blast cupola is mainly discussed, with mention of the OH, especially roof life when using O_2.

Safety in the use of oxygen R. Voit (**Linde Berichte aus Technik und Wissenschaft*, 1960, (9), 40–55) A detailed account of risks and the causes of fires and accidents and the measures, particularly in design of cylinders, valves, and such devices, for eliminating these hazards.

On the testing for gas-tightness of heat exchangers for gaseous media H. Weineck (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58, paper 44; no source given, pp.7) Gas-tightness of heat exchangers for gaseous media, including recuperators, is discussed and the various methods of measurement are considered. The author derives formulae for the determination of the losses from known aerodynamic equations, separately for laminar and turbulent flow. A numerical example is appended.—T.G.

Principal comments on a visit to eight American Open Hearth Steelworks L. Septier and M. Rivière (*Rev. Mét.*, 1960, **57,** Sept., 797–803) A report on eight steelworks using natural gas. Hot metal practice, regenerator, and refractory techniques are discussed.

The theoretical basis of oxygen steelmaking J. Pearson (*Iron Coal Trades Rev.*, 1960, **181,** Dec. 30, 1407–1413) A paper from the BISRA Steelmaking Conference, Oct. 12–13. Converter methods, especially the LD, are described with notes on Kaldo and Rotor.

Ore cooling in the basic oxygen steelmaking process J. Worsman (*Reg. Tech. Meet. AISI, Preprint*, 1960, Nov., pp.8) Experience at Kaiser Steel is briefly described. Reasons for the substitution of ore for scrap are given and effects are indicated.

Cooling the bath in oxygen-blown converters F. Krumnikl and R. Strobl (*Hutnik*, 1960, **10,** (10), 376–380) Theory and practice of cooling of the bath are reviewed, and a nomogram for the determination of the quantities of scrap to be used as coolants as a function of the bath composition is developed. In Czechoslovakia, cooling agents best suited to local requirements are scale in combination with lime and limestone. The possibility of using water or steam deserves attention; as yet this method has not been realized in practice.—P.F.

The production of steel by the LD process R. G. Walzel (*Revue ATB Mtt.*, 1960, **2,** (1), 13–30) This article deals with the historical development of the LD process, theoretical and practical aspects of the process, problems of heat recuperation and dust entrainment, properties and applications of the steel, economic aspects, and LD and LD–AC plants operating or under construction in the autumn of 1959.

Computer tightens control of LD steelmaking process W. J. Slatosky (*Steel*, 1960, **147,** Nov. 21, 115) The analogue computer, determining the proportions of hot metal, scrap, and lime to be charged into a furnace to top a particular type of steel at a specified temp., and mathematical equations permitting advance calculations, developed on the computer, are briefly discussed.—S.H.-S.

Iron balance in the oxygen top-blown converter process S. I. Lifshits (*Stal'*, 1961, (2), 109–112) Comparisons are made with the acid Bessemer and OH processes. Using high grade ore with low SiO_2 or concentrate briquettes without scrap, the top blown converter gives a yield of steel in good ingots not inferior to that of the OH. Iron losses are lower than in the bottom blown converter.

Study of the simultaneous course of droplet nucleation and growth, elucidated on the example of dust formation in converter processes of steelmaking L. von Bogdandy (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58, paper 21; reprint from *Zeitschr. für Elektrochemie*, 1957, **61,** (1), 222–226) The author develops an equation for the calculation of the simultaneous course of droplet nucleation and growth in the condensation of vapours. Using as an example the dust formation in the basic converter, good agreement exists between theory and measured grain-size of the dust particles as long as supersaturation is not too large (16 refs).—T.G.

Electron microscope study of metallurgical dusts, particularly their preparation and their physical discrimination A. M. D'Ans and L. von Bogdandy (*Hüttenwerk Oberhausen, Tech. Ber.*, 195.–58, paper 19; reprint from *Proc. Stockholm Conf. on Electron Microscopy*, 1956, 328–331) The dust consists mainly of Fe_2O_3 and has a grain size of about 10–100 mμ. Preparation of the dust samples for observation in the electron microscope is also described. Ultrasound was used in the preparation for suspension of the dust in liquids, such as water, acetone, or alcohol. From the results it is concluded that the dust from converters leaves the converter in the metallic state. This view is supported by optical extinction measurements.—T.G.

The reactions taking place in rotating vessels during blowing with oxygen P. E. Hardt, G. Vocke, and H. Schenck (*Stahl Eisen*, 1961, **81,** Feb. 2, 155–163) Refining tests were carried out on basic Bessemer lines in rotating vessels of circular and elliptical cross-section. The highest dephosphorization rate was found in elliptical vessels of an axial ratio of 1:1·5 at speeds of 14–16 rpm. Higher speeds were deleterious for several reasons. Desulphurization in the elliptical vessel was excellent, above 1600°C increased desulphurization via the gas phase was observed.—T.G.

Energy requirements of the Ajax steel making process A. Jackson and S. H. Brooks (*J. Inst. Fuel*, 1960, **33,** Dec., 580–584) The heat balance shows the thermal efficiency, including heat recovery, to be 75%. OH and other O_2 processes may be capable of recovering more heat units in steam but the Ajax process makes the fullest possible use of the heat generated in the furnace and absorbs any excess by endothermic decomposition of ore thus adding metallic Fe to the bath and increasing metal yield. The vessel is less compact than some others of the O_2-processes but insulation keeps losses down to 12½% of input heat. Due to efficient dust collection and relative high Fe content of the material collected in the slag pocket, Fe recovery via the blast-furnace is considerably greater than in the

standard OH practice. The Fe is phosphoric and using 100% gives a relatively heavy metallurgical load but an increased production (50% in modern furnaces, 100% in the oldest) was achieved. Refractory consumption has now fallen in lb/t to about 60% of former OH practice and fuel is ~9 therms in comparison to 40–45 with standard practice; O_2 is lower than with a modern O_2-blowing process using 100% metal of this analysis. Possibly fuel could be further reduced by using more O_2 but this would not necessarily be economical. In summary it is found that the conversion cost of turning charged raw materials into ingots is reduced to 68% of that with standard OH practice.

The metallurgical basis of the 'Phoenix' oxygen lance process of steelmaking E. Schürmann, K. K. Aschendorff, H. Höfges, and E. Köhler (*Stahl Eisen*, 1961, **81,** Feb. 2, 163–172) The authors discuss the main metallurgical reactions involved in the 'Phoenix' oxygen lance steelmaking in process the presence of the first slag. The overriding effect of the lime on slag formation and on the final composition of the slag is stressed. The results show the genuine advantages offered by the Phoenix lance, resulting in an increase in steel quality that widens their application, for instance as deep-drawing steels.—T.G.

Porous refractory used in gas treatment of metal F. Schneider (*Steel*, 1960, **147,** Dec. 19, 108–109) Fine bubbles of gas are dispersed through a ladle of molten metal by means of a plug of porous refractory. It has been used for flushing hydrogen from nonferrous materials, providing agitation for speeding slag-metal reactions, and mixing ladle contents, nitrogen, and argon being the gases most commonly used.—S.H.-S.

Open hearth furnace or oxygen blown converter (In the form of a discussion) A. F. Myrtsymov (*Stal'*, 1961, (1), 21–24) Technical and economic advantages of the converter process are considered and the general construction of converter installations as OH furnaces require replacement is advocated, given O_2 of not less than 99·5% purity with arrangements for drying the blast.

A review of the book 'Open hearth shops with large furnaces' by D. A. Smolianenskov and N. I. Efanov (Metallurgizdat 1960, pp.353) N. A. Vecher, G. E. Germaidze, M. I. Panfilov, M. M. Zhil'ko, N. P. Mershchii, K. S. Alferov, S. P. Antonov, E. I. Dikshtein, M. I. Yagnyuk, K. N. Belikov, Ya. A. Goncharevskii, A. G. Trifonov, and G. A. Sedach (*Stal'*, 1961, (2), 125–126) The review is generally favourable but some omissions and some out-of-date sections are pointed out.

Scrap for steelmaking in open hearth furnaces C. G. Campbell (*Reg. Tech. Meet. AISI*, 1958, 381–391) Availability and cost of transport of scrap is considered. Layouts of the facilities for handling and processing scrap at Pueblo, Colorado, are shown.—C.V.

The use of a lime–iron oxide sinter in the basic open-hearth furnace W. Fiedler (*Freiberger Forschungsh. Met.*, 1960, **(B43),** pp.64) Fe_2O_3 is an excellent flux for CaO, the melting point of which is high above the processing temp. in the OH furnace. For this reason an intimate mixture of CaO and Fe_2O_3—unfortunately the eutectic was not practicable, an excess of CaO had to be used—was sintered to pellets and charged. It was found that a low-viscosity, highly reactive slag was soon produced; output was higher by about 4–9%; excellent dephosphorization was obtained; desulphurization was not impaired; the lining was less damaged than under normal conditions; the oxidation rate of the sinter for carbon is less than that of the equivalent quantity of oxide in mill scale or the like, i.e. more sinter than mill scale must be used (46 refs).—T.G.

Scope for raising the levels of technical and economic efficiency of steel production in the Third Five-Year Plan K. Niemiec (*Hutnik*, 1960, **10,** (12), 463–464) The planned increase of steel production during the next five years pre-supposes an increase of over 30% in productivity. In steel production, hidden reserves exist in the OH process, as this could be accelerated appreciably by using pre-refined iron in the charge, e.g. refined in the runner on its passage from mixer to tundish.

How new open hearth technique doubles steel output G. A. Ferris (*Iron Age*, 1960, **186,** Oct. 20, 158–160) Operating and production data for the new Ford OH steelmaking process is briefly reported with results, and technique for which a 50% time economy in making a ton of steel conventionally in the same 200-t furnace is claimed.—S.H.-S.

The production and application of magnesia–alumina bricks for roofs of open-hearth furnaces in China Guan Zong-shan and Wang Yun-he (**Gangtie*, 1958, Sept., 19–24) A summary of trials in comparison with chrome–magnesite bricks is given indicating a life estimated at 600 heats (not obtained on account of scheduled shut-downs). Their extensive use is recommended.

On the question of reducing open hearth down-time for repairs V. I. Zhivago and A. I. Fidel'man (*Stal'*, 1961, (1), 77–78) A discussion of a paper by V. M. Sobolev and S. E. Gershogorin (*ibid.*, 1959, (10)) in which the measures there recommended of building reserve furnaces and carrying out scheduled repair schemes are criticized in favour of the use of available means of automation and mechanization. Possible savings are estimated.

Spalling parameters of silica open-hearth roof brick determined by hot-plate test G. R. Eusner and K. K. Kappmeyer (*Amer. Ceram. Soc. Bull.*, 1960, **39,** Sept., 448–452) A hot plate was developed to evaluate the low-temp. spalling resistance of silica open hearth roof brick and possibly other materials sensitive to this type of spalling. Increase in Fe_2O_3 content and coarse grain size are most effective in increasing resistance.—C.V.

The economics of enhancing open-hearth steelmaking efficiency by the use of liquid cupola iron S. Hájek (*Hutník*, 1960, **10,** (10), 384–386) A fuller use of capacity in small OH steelworks is shown to be attainable by the availability of cupola iron.—P.F.

The comparative economics of melting killed carbon steel in large holding capacity open-hearth and electric furnaces V. M. Tsitver and M. I. Klebanova (*Stal'*, 1961, (1), 74–76) Operation of OH furnaces is lower in cost than that of electric furnaces and capital costs are about the same. Conditions under which this might be reversed are indicated. Actual costs of electric furnace installations are lower but power, transport, and fuel costs bring them up to approximate equality.

Opening of tap holes of open-hearth furnaces with explosive lances W. Burmeister (*Hüttenwerk Oberhausen, Tech. Ber.*, 1955–58, paper 14; source not given, pp.5) Jet tappers first used in the USA for opening the tap holes of OH furnaces were also employed in Germany after 1954. The tappers are now made under licence in Germany and the author reports experience gained in their use for opening about 12000 tap holes in the last few years. The savings obtained in the use of these tappers are also discussed.—T.G.

Steam injection in open-hearth furnaces A. Bichler (*Hutn. Listy*, 1960, **15,** (10), 778–781) The effect of steam additions to a 150 t OH furnace with silica roof, at a rate of 1 t/h were studied. The steam was at a pressure of about 20 atm at 250°C, and was injected below the flame. Similar experiments were carried out on a 200 t furnace, having a basic roof, run on a mixture of blast-furnace, and coke-oven gases with oil carburetting. It was shown that no increase of H_2 uptake occurred; the steels were clean, deep drawability was good, and ore consumption was reduced. Steam injection is recommended.—P.F.

Studies of desulphurization kinetics of iron by means of ^{35}S L. S. Chen, J. Skála, and M. Mandl (*Hutn. Listy*, 1960, **15,** (10), 755–762) By means of ^{35}S, desulphurization was studied in the systems Fe–C–S, Fe–C–S–Mn, and Fe–C–S–Si under $CaO–Al_2O_3–MgO$ and $CaO–SiO_2–Al_2O_3$ slags, Mn in concentrations of less than 8% retards desulphurization with both slags; silica acts similarly only under slags containing MgO. In desulphurization under slags containing 30%SiO_2, Mn accelerates desulphurization. The rate of transfer of sulphur from metal to slag is controlled by the diffusion of bivalent sulphur ions in slags free from silica, and by the rate of the chemical reaction with slags containing 30% or more of silica.

Dependence of the desulphurization process in steel on the conditions of mass transfer B. N. Ladyzhenskii and A. D. Bashmakov (*Stal'*, 1961, (1), 29–30) Rate of equilibrium determines the overall rate in a sequence of reactions, especially that of the slowest step. Rate of mixing may be an important factor. Injection of powdered material increases slag–metal interface area and reduction in depth of layers in reacting phases improves diffusion and may improve slag utilization.

The basic Bessemer electric furnace duplex process M. Brocard (*Rev. Mét.*, 1960, **57,** Sept., 775–782) The metallurgy and technology of the process are described and discussed, and its economics reviewed.

Recent electric furnace steelmaking N. Fujioka (*Tetsu to Hagane*, 1960, **46,** Oct., 1475–1490) [In Japanese] A review.

The electrical equipment of the modern arc furnace P. Bonis (*Rev. Mét.*, 1960, **57,** Sept., 783–796) The influence of the increase in capacity and power of modern arc furnaces on the design and characteristics of their electrical equipment is reviewed, e.g. circuit breakers, transformers, and electrode controls, and six types of electrode control are discussed, electric and hydraulic.

Furnaces for S.P.T.—Mechanical and electrical details of ultra-large units (*Iron Steel*, 1961, **34,** Feb., 63) Four electric arc melting furnaces are being built for Steel, Peech & Tozer as part of the £10 million development programme. The design is that of Demag-Elektrometallurgie with a nominal capacity of 150 t; they are to be worked with 110-t charges in order to have a shallow bath and large surface area. The arrangement of the electrode supporting structure and roof raising mechanism is described together with the mounting arrangement which enables the furnace to be tilted forward 45° for pouring and backward 15° for slagging. The electrical aspects (transformer, winding, current, arc, electrodes, water-cooled flexible cables, etc.) are summarized.—C.V.

Metallurgical study of electric furnaces: type samples of manufacturers G. Grenier (*J. Four Elect.*, 1960, **65,** Nov.–Dec., 273–277) A review, with analyses, of four main types of steel: rustless with 13% chrome; rapid machining 18–4–1 steel; Mn, Al, and Si steels; valve and magnet steels; refractory alloys. Methods of production are briefly described.—S.H.-S.

Reconstruction of fixed roof electric arc-furnaces for top charging J. Dejl (*Hutník*, 1960, **10,** (10), 381–384) Simple methods suitable for the modernization of arc-furnaces are discussed with special reference to designs developed by the author.—P.F.

Improved technology for melting constructional alloy steel S. G. Voinov and L. F. Kosoi (*Stal'*, 1961, (1), 34–38) Improved quality, better phosphorus removal, and 15% increased output is claimed for arc furnace operation with rigid compliance with thermal and slag conditions and deoxidation with Al.

Improving roller bearing steel quality by electroslag remelting I. Petrman and I. Kašík (*Hutn. Listy*, 1960, **15,** (11), 839–851) Roller bearing steels containing 0·95%C, 1·36%Cr, 0·24%Cu, 0·2%Ni, 0·35%Mn, 0·02–0·16%Si, 0·013%S, and 0·03%P were remelted in a single-phase electric furnace by the electroslag method. Macro- and micro-structure, wear resistance, and other properties were improved. Thirty-two melts were studied; on the average remelting resulted in halving the sulphur content.—P.F.

Study of mould-iron compositions J. R. Kattus (*Reg. Tech. Meet AISI, Preprint*, 1960, Nov., pp.36; from *Blast Furn. Steel Plant*, 1961, **49,** Feb., 159–163) Laboratory fatigue tests and behaviour in service of grey and Mg-treated irons are reported. The grey irons behave better in the steelworks but semi-nodular fatigue values are higher. A parameter characterizing actual performance is derived. An equation is given which enables the service life of an ingot mould to be correlated with the thermal and mechanical properties of the materials used. In this, thermal conductivity, ultimate tensile strength, modulus of elasticity, coefficient of thermal expansion, % elongation, and the slope of the strength-temp. curve are

considered. Suggestions are made for the extension of this work and 29 refs are discussed.—C.V.

Teeming of electric steel using wooden frames N. V. Keis, D. G. Zhukov, T. I. Malinovskaya, and A. M. Vikharev (*Stal'*, 1961, (1), 38–39) Rejects are much reduced by inserting wooden frames into the ingot moulds.

Conservation of heat in the feeder heads of 8–15 ton slab ingots for rolling S. Ya. Skoblo, V. G. Strakhov, Yu. I. Kiryushkin, I. S. Chernyshev, and T. I. Oleshkevich (*Stal'*, 1961, (2), 119–123) To reduce the discard, hot topping is improved by use of a two-layer system of foamed fireclay and protective firebrick respectively 115 and 40 mm thick. The relative volume of the feeder head is reduced 2·5–4%.

Tigerschield hot-topping practice at the Dalzell works of Colvilles Ltd T. Harris (*Iron Coal Trades Rev.*, 1960, **181,** Sept. 9, 563–566) The use of 'Tiger' hot tops has increased axially sound yields by 6–7% of slabs or billets with consequent reduction in cost of rolled prime product, has reduced conditioning cost of the rolled products through the elimination of 'hanger' cracks in the ingot, has reduced head costs through the elimination of head castings and replacement of skilled bricklaying and moulding headsmen manpower by labourers, and has reduced casting pit congestion through minimizing the type and number of moulds required for varying weight ingots. This has had the indirect effect of reducing tapping delays caused, for example, by waiting for setting of the pits. For forging blooms and plate manufacture, where exact weights are required from the ingots, the ability to vary actual ingot weights is a great advantage. The life of these redesigned moulds exceeds those which were replaced.—C.V.

Production of high-carbon killed steel ingots without using hot tops J. G. Wilson (*Iron Coal Trades Rev.*, 1960, **181,** Sept. 9, 566–568) The various changes in plant conditions at the Normanby Park Steelworks during the 1945–1951 period are indicated and there was a gradual change from 19in to 23in ingots which necessitated a redetermination of the freezing time and C-steel production had risen from 40 to 700 t/week the C-specification changing from 0·40 to 1·0%C. The necessity of controlling the teeming temp. was realized. This is discussed, but a re-examination of the problem showed two inherent disadvantages that might arise from longer standing; longer times in the mould would reduce mould life and charging of cooler ingots might increase soaking times and fuel per ton for heating. No evidence in this direction was obtained but it is considered possible that this may be concealed since the total C-steel produced per week is only 6% of the total output. The conditions for obtaining high yields depend on the formation of a solid top crust which will prevent oxidation of the major pipe during soaking and the formation of a solid zone between the major and secondary pipes. None of the 4-ton ingots was sectioned and the conclusion is based solely on bloom and billet examination. The insertion of hot-top tiles often destroyed the junction between the two pipes giving a 50% piping down the ingot. It is possible that subsequent mechanical working to the billet stage promotes C-diffusion. The distribution of C from top to bottom of the ingot is shown.—C.V.

Study of the gas pick-up and the gas evolution of teemed steel during pouring of heavy ingots for forging E. Schürmann, M. Hater, and A. Fricke (*Stahl Eisen*, 1961, **81,** Feb. 2, 172–183) The authors studied the gas pick-up, mainly oxygen, by streaming, killed steel during teeming of 78-t forging ingots. They found —at normal atmospheric pressure—an increase in O_2 content of 100% relative to the O_2 content of the steel in the ladle. When the stream of molten steel was covered this figure was reduced to 10%. During the latter test it was found that considerable quantities of CO and CO_2 were given off, as well as of H_2. The kinetics of gas evolution are discussed.—T.G.

Continuous casting gains abroad (*Steel*, 1960, **147,** Nov. 21, 106–108) The performance of continuous casting plants in Austria, France, and Italy, their present operation and potential, are briefly described.—S.H.-S.

Progress of continuous casting in speciality steel production R. Clark and W. A. Thomas (*Reg. Tech. Meet. AISI*, 1958, 471–494) A schematic drawing of the continuous casting installation at Atlas Steels Ltd is given. The flow of metal is from the ladle into the refractory-lined tundish, then to the water-cooled copper mould where the initial shell of metal is formed. The solidification process is completed in the secondary spray cooling chamber, the heat being extracted by direct water spraying. Pinch rollers support the weight of the billet and control the rate of withdrawal from the mould, the casting being then cut into lengths by twin oxy-acetylene powder torches and discharged from the machine. The mould sizes selected were 5½ × 21½in slab for stainless flat products (sheet and strip), 5½ × 7½in section to be used for alloyed steels such as Si valve steels and intermediate billets produced in other grades; neither of these two sizes was designed to by-pass the blooming mill but only to by-pass the ingot stage and a 4½in square which was designed for high alloy tool steels or coils and small bar products of any grade so that the ingot casting stage and primary cogging units could be by-passed. These mould sizes were later replaced by ones measuring 6½in × 24in, 7in × 15in, and 6½in × 6½in, and even 7in × 8½in is how being considered. The various changes in equipment and technique that have been introduced are discussed. The major variables that must be controlled are casting temp. of the steel and rate of casting and the avoidance of excessive internal cracking and porosity are specially examined.—C.V.

Solidification of ingots of 18–30 KhGT steel and improvement of their quality M. I. Kolosov, A. I. Stroganov, O. Ya. Vainshtein, N. V. Keis, and V. A. Khryukina (*Stal'*, 1961, (1), 25–28) The reasons for laminations in rolling have been found and better teeming and hot tops were tried. Better deoxidation was found to be the remedy.

Improving the resistance of steel ingots to cracking A. A. Kiselev and V. I. Yavoiskii (*Stal'*, 1961, (2), 112–119) Low carbon steel ingots have a reduced cracking tendency when poured at a reduced rate, increasingly deoxidized with Al and cast into ingots with corrugated surfaces. The factors producing strain, which these practices reduce, are given.

Phenol removal from steelworks effluent—a status report P. W. Sherwood (*Brit. Steel*, 1960, **26,** Nov., 378–379, 393) Methods of phenol removal from waste streams are outlined, and compared and subdivided according to whether the removed phenols are recovered for subsequent sale.

PRODUCTION OF FERRO-ALLOYS

Ferrosilicon raw materials and production H. Hagerup-Jenssen (*Industrie Information*, 1959, (7), 83–100) [In English and German] A review analysing the basic materials and reduction materials and the operations involved in the products of the Norwegian ferrosilicon industry is presented with descriptions of the equipment, and a flow-sheet, and illustrations.

Ferrosilicon—a national product of Norway A. M. Aas (*Industri Information*, 1959, (7), 11–20) [In English and German] The President of the Norwegian Ferrosilicon Producers' Association demonstrates the prerequisites of geology, geography, and power supply economy which have made Norway the world's greatest ferrosilicon exporter, and also provides a survey of the Norwegian ferrosilicon industry.—S.H.-S.

Ferrochrome decarburized by blowing with oxygen in the converter P. A. Sakharuk, G. D. Dmitrovskaya, and O. V. Geev (*Stal'*, 1961, (1), 40–42) The thermochemistry of the process is outlined and practice at Aktyubinsk is described with a plan of the converter used. Vacuum treatment is recommended using a special converter lining.

Technology of smelting ferromanganese in blast furnaces I. I. Korobov, V. I. Sorovov, P. G. Goncharov, and A. M. Zhak (*Stal'*, 1961, (2), 107–108) A comment on the article of Shumakov and Chasovitin (*ibid.*, 1960, (2)) pointing out that conditions at Petrovskii are different from those in the Urals as a different ore is used and would require a different basicity from that advocated by the previous authors. Experience over a period at Petrovskii is described.

FOUNDRY PRACTICE

Report of Committee A-3 on cast iron ASTN Committee A-3 (*Proc. ASTM*, 1959, **59,** 124–126) Various standards and tentative standards are revised and the amended wordings are given.

Foundry technology—Where is it headed? (*Foundry*, 1961, **89,** Jan., 68–77) A comprehensive survey, giving the views of 22 research men and educators on current and future developments in foundry technology and education, is presented and analysed.—S.H.-S.

Castings—from fracture to strength (*Engineering*, 1961, **191,** Jan. 13, 46) The similarity between the Metalock Key and the old fashioned 'link' or blacksmith's 'dumbell' is stressed and examples are shown of repairs carried out by this technique. In most cases it is applied to iron castings but with experience it has been used with steel castings. Fabricated steel units are also considered. It is considered that any casting more than ¼in thick can be successfully repaired and steam pressures to 500 lb/in² or hydraulic to 7000 lb/in² have been contained. Temp. limit is 1500°F except in gas retort castings, slag ladles, and ingot moulds.

Navy will set new casting standards R. J. Ely (*Steel*, 1960, **147,** Dec. 5, 106–108) Obsolescence of existing inspection standards, due to progress in the casting of light steel sections for aircraft and missiles, has caused the placing of a contract for the production of *defective* castings for the setting of new acceptance standards. The specifications for the new casting procedure and the radiographic operations involved in the programme are presented.

Modernization slashes costs, castings replace stampings J. Van Haver (*Mod. Castings*, 1961, **39,** Feb., 44–47) New equipment and green sand moulding methods have increased productivity by 200% and reduced costs by 30%. These changes are described and illustrated.

The running control laboratory in the foundry (*J. d'Inf. Tech. Fonderie*, 1961, (122), Jan., 17–20) The principles and conditions requisite for the establishment and operational functions of a foundry control laboratory are discussed, with four diagrams.—S.H.-S.

7 Ways to solve steel castings' slow growth problem J. Schaum (*Mod. Castings*, 1960, Nov., **38,** 29–32) A review of the problems facing the industry, and of the ways in which these difficulties may be resolved.

Human factor and the design of foundry machines and equipment J. Lempicki (*Prz. Odlew.*, 1961, **11,** (1), 22–25) The size, the controls as well as the area served by any foundry machine should be designed with regard to economies in the movements and ability of the operator so that the design underlying it could be fully utilized.

Squeeze the safety factor, allow less for ignorance T. O. Kuivinen (*Mod. Castings*, 1960, **38,** Nov., 44–46) The importance of test data, their correlation with practice, and the desirability of better coordination of effort between foundrymen and designers is discussed.

The effect of the melting atmosphere on the structure of cast iron G. Ohira and K. Ikawa (*Imono*, 1960, **32,** April, 241–251) Hypo-eutectic, eutectic, and hyper-eutectic Fe–C–Si–P alloys were melted *in vacuo*, and the atmosphere was then modified to contain any desired mixture of N_2, H_2, CO, and argon. The effect of the chosen atmospheres on the structure of the resulting iron was noted. Some explanation of the results is given. The effects of S were also examined.

Tendencies of development of cast irons, for use in machine tool construction G. Quapil (*Technik*, 1960, **15,** 757–762) A review of the various types of cast iron available, their use in machine tool construction, and their properties, with special emphasis on high-strength, corrosion-resistant, and high-temp. types.—T.G.

Production installations of the new foundries of Gebruder Sulzer F. Eisermann (*Berg-Hütten. Monatsh.*, 1960, **105,** Aug., 186–192)

The planning, layout, and equipment of the new grey iron and steel foundries of Gebrüder Sulzer at Oberwinterthur are described.

The largest malleable iron foundry in Africa J. H. Peers (*Inst. Brit. Found. Aust.*, 1960, **11**, 43–62) The South African malleable foundry described commenced operation in 1944 and has rapidly expanded until today more than 7000 t of castings are produced annually. A detailed description is given of the foundry production departments and reference made to some novel materials-handling methods developed. Mention is also made of the heat-treatment cycles employed and some of the steps taken to overcome casting defects encountered in the production of malleable iron castings.—C.F.C.

Durgapur iron and steel foundries (*Found. Trade J.*, 1961, **110**, Jan. 12, 34–44) A brief initial survey of the project is presented followed by a detailed description of the foundry, buildings, equipment installed, and the flow-process schemes to be operated. A supplementary note describes progress up to the present, stating also that wheel sets for the Indian railways will be produced early in the autumn of this current year with an ultimate annual production of 45 000 sets. The total ferrous castings output is planned for 30 000 t per year.—S.H.-S.

New foundry specializes in large steel castings R. H. Herrmann (*Foundry*, 1960, **88** July, 72–75) Production of steel castings of 35 000 to 65 000 lb, supplied by a basic-lined electric arc furnace of 100-t holding capacity at General Electric Co.'s Schenectady, NY, iron foundry (which has been converted to meet demand for steel castings) is described, with use of induction stirrers facilitating economical use of chips, and, after casting, burning off risers by oxyacetylene torch.—S.H.-S.

New Brazilian foundry equipped with Italian electric induction furnaces M. Calamari (*J. Four. Elect.*, 1960, **68**, Nov.–Dec., 277–278; from *Fonderie Ital.*, No.5, 110) A new foundry in course of construction at Rio de Janeiro being equipped with 29 electric furnaces, with gas as alternative heating in case of current failure, is briefly described.—S.H.-S.

American automobile developments and their implications to founders (*Found. Trade J.*, 1960, **109**, Dec. 22, 787–792) Statistics of production and the growing use of Al are described. Estimates for demand for cast iron are given.

Industrial engineering in the foundry industry. A survey M. T. Sell (*Mod. Castings*, 1960, **38**, Nov., 65–72) The results of a questionnaire sent out to foundries are given. Wage payment plans, premium earnings, indirect labour operations, control methods, are covered. Industrial engineering department duties are also discussed.

Safe lifting gear in the foundry C. H. A. McCaully (*Iron-founding Health and Safety*, 1960, 60–65) The various aspects are examined and the influence of temp. on the factor of safety is discussed. At 250° full strength is found, at 300° it is 0·94 times the safe working load at room temp., at 400° this is reduced to 0·72 while at 450° it has fallen to 0·58. Other aspects are discussed.—C.V.

Handling materials with magnets R. H. Herrmann (*Foundry*, 1961, **89**, Jan., 62–64) A system in an Ohio malleable iron foundry making extensive use of overhead bridge cranes equipped with lifting magnets for handling metal and castings in the melting, cleaning, and heat-treating departments is described and illustrated.—S.H.-S.

How to select magnetic separation equipment H. W. Buus (*Foundry*, 1960, **88**, Dec., 74–76) Five major uses for magnetic separation equipment in salvaging sand and tramp metal, and protecting equipment and personnel, with methods for their selection, installation, and research testing, are presented, with two typical charts of results.—S.H.-S.

Molds handled automatically in casting of bathtubs (*Foundry*, 1960, **88**, Dec., 82–84) Plant, equipment, and operation are described whereby seven men, operating an automatic system producing bath tub moulds, weighing up to 7 t each, including flasks, sand, and casting, can turn out moulds at the rate of 72 per hour. Shuttle indexing of moulds and automatic sand metering are basic features.

Technical control in steel foundries in North America C. B. Jenni (*Found. Trade J.*, 1961, **110**, Jan. 19, 69–77; Jan. 26, 101–106) A paper, which was the exchange lecture under the BSCRA reciprocal scheme with the Steel Founders' Society of America, embodies a survey of the whole field of process control in the American steel-founding industry, from raw materials to quality of product. The first section completes the survey concerning metal preparation and melting, being the first portion of nine main sections, to the end of the section devoted to steelmaking. The second section continues the survey with a review of foundry practices and carries this topic into the sphere of fettling and shotblasting procedure.—S.H.-S.

Reducing the scrap in an iron foundry Mavor and Coulson Ltd (*Engineering*, 1961, **191**, Jan. 6, 38) A detailed investigation of this problem in a Scottish iron foundry led to a saving of £24000 in a year; the details are analysed.—C.V.

Some results of investigation in a metallurgical blast cupola R. Doat, H. Doutreloux and H. de Rycker (*Fond. Belge*, 1961, **31**, Jan., 3–11) Measurements and observations on a metallurgical blast cupola with a melting rate of 10 t/h are reported. Trials on the raw materials descending through the cupola showed, near the tuyere nozzle, a zone where iron ions oxidized to magnetite and that in an extremely hot lower zone both the magnetite and the Mn and iron oxides present in the slag were reduced. High temp. reduced losses in Fe, Mn, and Si with higher coke consumption.

The design and operation of the cold blast acid-lined cupola H. J. Leyshon and F. Dunn (*BCIRA J.*, 1960, **8**, Nov., 825–837) General principles of design are outlined. Blower capacity, coke bed preparation, charge weighing, and size of materials, changes in composition during melting and slagging methods, and repairs are referred to.

Trials with basic cupolas O. Gerstmann (*Giessereitechnik*, 1960, **6**, Sept., 279–280) A report given at a Colloquium held on 30 April, 1960, at Zentralinstitut für Giessereitechnik, describing trials with magnesite-lined cupolas.

Basic cupola melting and its application S. Yamashita (*Imono*, 1960, **32**, April, 268–279) The economic advantages of basic cupola melting are discussed, and the improvement in the properties of iron made in this way are considered.

Trouble shooting. Small cupola practice C. W. Ammen (*Foundry*, 1960, **88**, July, 194–195) Problems arising from the intermittent operation of a small cupola are discussed and some remedies suggested.—S.H.-S.

Installation and operation of hot-blast cupola R. W. Leslie and J. E. Waterman (*Castings*, 1960, **6**, Aug., 25, 27, 29) A summary of a paper for the Inst. of Australian Foundrymen.

Determination of linear rate of coke combustion and the height of the combustion zone in the cupola C. Podrzucki (*Prz. Odlew.*, 1961, **11**, (1), 4–11) A formula is given that relates linear rate of combustion to the amount and temp. of the blast, its oxygen percentage, and physical as well as chemical properties of the coke used. The formula allows the calculation of the combustion zone. The formulae obtained have been confirmed by laboratory tests.

Technical measurements for cupola control K. Šafář (*Slévárenství*, 1960, **8**, (12), 435–436) Efficient working of cupolas necessitates measurement and control of such variables as pressure and moisture content of the blast, composition, and temp. of cupola gases, and temp. of the metal. Equipment suitable for these purposes is discussed, and the control of cupola performance on the basis of the measurements so obtained is considered.

Melting in water-cooled cold blast cupolas H. Thalmeier (*Giessereitechnik*, 1960, **6**, Sept., 266–269) The construction, mode of operation, heat balance, and metallurgy of the water-cooled cold blast cupola are outlined.

Situation of refractory materials for cupola furnaces both at the present time and in the future S. Wakabayashi (*Imono*, 1960, **32**, May, 316–318) [No Summary].

Consideration of the erosive action of acidic fire bricks in the cupola T. Makiguchi and T. Hayashi (*Imono*, 1960, **32**, May, 319–325) The amount of silica in firebrick was varied, and the effect of silica on erosion was assessed in this way. Higher SiO_2 gives higher viscosity at elevated temp. A brick with a pyrophyllite base gave good service.

Tests on dolomite refractory bricks for the cupola Y. Ino and S. Fukui (*Imono*, 1960, **32**, May, 326–329) The effect of heating dolomite brick to 1450–1500°C, and holding for 8 h, and the effect of cycling between this and room temp. are described and the results of the tests are discussed.

A test for the patching materials made in the U.S.A. T. Ota, A. Wakabayashi, and S. Fukui (*Imono*, 1960, **32**, May, 330–335) A patching material of composition SiO_2 85·5–87·9%, Al_2O_3 7–7·8·0%, Fe_2O_3 0·63–0·93% was tested for refractoriness, grain size distribution, compressive strength, softening temp. under load, and coeff. of expansion.

The results of the experimental use of a siliceous material for cupola lining repairs H. Tamura (*Imono*, 1960, **32**, May, 335–340) 'Daubpax' was chemically analysed, the grain size distribution was examined, and green compressive strength erosion resistance, cost, and effectiveness were studied, the last two in comparison with pyrophyllite material, to which it is generally superior, but more expensive.

Trial production and practice test of a new type of patching material for the cupola T. Ota and Y. Nishikawa (*Imono*, 1960, **32**, May, 340–345) Very good results were obtained by the use of a mixture of coarse quartzite grains and fine pyrophyllite grains.

Summary of refractories used and their conditions of use for cupola melting in Japan N. Tsutsumi (*Imono*, 1960, **32**, May, 346–349) An investigation into the use of refractory materials was carried out at 15 foundries and three research institutes. The results obtained are summarized under these headings: Cupola capacity, size, and form; melting operation; repairing; firebrick used; patching materials used; other refractories used; requests and anticipations of the Refractory Committee of the J.F.S.; requirements to manufacturers. An opinion and criticism by the Committee is also given.

Refractory lining and lining repair on cupolas —compilation of enquiry Y. Ino, C. Saito, and Y. Nishikawa (*Imono*, 1960, **32**, May, 350–364) [No Summary].

Concerning the survey on the form and size of fire brick for the cupola T. Makiguchi (*Imono*, 1960, **32**, May, 364–367) The form and size of the firebricks currently used in Japan and the incidental items related to cupola lining were investigated. There is a tendency towards the replacement of ordinary firebrick by special firebrick, although at present the greater part of the bricks used are still the normal ones.

Standard shapes for cupola lining bricks S. Wakabayashi and M. Fujii (*Imono*, 1960, **32**, May, 367–370) In order to facilitate the construction of cupolas with internal dia. of 450–1800 mm, certain standard brick shapes are proposed, based on the Japanese Industrial Standard (230 mm × 114 mm × 65 mm) brick.

The relationship between method of cupola operation and erosion of refractories in the melting zone Y. Minami and Y. Tsukagashi (*Imono*, 1960, **32**, May, 371–377) It has been found that the ratios of effective height to dia. at tuyere level, basket type of charging machine, ore–coke ratio, limestone %, and blast volume or condition have a considerable influence on erosion, and there are some special relations between the velocity of erosion and blast pressure.

Cupola spout temperature measurement R. Rew (*BCIRA J.*, 1960, **8**, Nov., 821–824) The use of an immersion thermocouple is described, and compared with a radiation pyrometer technique.

How to make different irons from a single cupola heat F. E. Kasch (*Mod. Castings*, 1960, **38**, Dec., 46–50) The variables that affect iron composition, methods of modifying the composition, and tests available to check such changes quickly are considered.

Water cooling, and carbon lining promote

flexible cupola operation Neenah Foundry Co. (*Foundry*, 1960, **88**, April, 146, 149) The operation of two cupolas, rated at 11 and 8 t/h, combining the advantages of external water cooling and carbon-lined well zones, permitting flexibility in changes in slag analysis from acid to basic and back again under close control as desired is briefly described with a report on refractory savings.—S.H.-S.

Progress made in the use of ferrous products in the car industry J. Pomey (*Ind. Nat.*, 1960, (4), 87–104) The author discusses present methods used in casting, shaping, and thermal treatments of ferrous car components. Theoretical as well as practical aspects are dealt with.—R.P.

Catalogue of Italian firms producing plant, machinery, equipment and products for the foundry (*Fonderia*, 1960, **9**, Sept., 379–410) [In Italian].

The foundry industry in Japan. Impressions of a visit M. Olivo (*Fonderia*, 1960, **9**, Oct., 456–459) A general survey is given together with statistics relating to the production of various types of castings, productivity, use of labour, degree of mechanization, and type of equipment used.

IBF visits to works (*Found. Trade J.*, 1960, **109**, Oct. 13, 455–462; Oct. 20, 493–500) The works to be visited include, Newton, Chambers & Co., Ltd, Millspaugh Co. Ltd, Brightside Foundry & Engineering Co. Ltd, Osborn Foundry & Engineering Co. Ltd, Titan Foundry, Philadelphia Foundry, Osborn Precision Castings Ltd, British Steel Castings Research Assoc., Staveley Iron and Chemical Co. Ltd, Sheepbridge Engineering Ltd, English Steel Castings Corporation Ltd, and Hadfields Ltd.—C.V.

Six Danish foundries National Foundry College (*Foundry Trade J.*, 1960, **109**, Sept. 15, 321–329) A visit is described and the essentials relating to layout, equipment, and production are indicated.—C.V.

A foundry forge plant in India R. Brabenec (*Czech. Heavy Ind.*, 1960, (11), 34–41) The new plant supplements the metallurgical works already erected and is designed to produce 95 000 t of castings immediately and 155 000 t per year in the third stage. Illustrations and plans are provided.—C.V.

Sulzer's new foundry (*Found. Trade J.*, 1960, **109**, Nov. 17, 629–638) The new foundry at Oberwinterthur (Switzerland) is described in some detail on the occasion of a visit from the International Foundry Congress.—C.V.

The scientific organization of foundry operations J. J. Fernandez Fernandez (*Fonderia*, 1960, **9**, Oct., 431–444) Subjects dealt with include work study and analysis of operations, time study, preparation of instruction manuals, central direction of operations.

Planned investigation reduces foundry scrap Production Engineering Ltd (*Metalw. Prod.*, 1960, **104**, Oct. 12, 78–79) A scientific analytical investigation based on an experimental programme which reduced scrap levels by 16% to 8% of production, with a saving of £24 000 a year in a British iron foundry is briefly described with a list of changes in method and results.—S.H.-S.

Internal transportation in foundries H. Reininger (*Europäischer Maschinen Markt.*, 1960, **10**, (5), Dec., 16–18) [In English] By means of practical examples it is shown that internal transport costs can be reduced by suitable mechanization.—R.P.

Air conveying cuts additive handling costs (*Foundry*, 1960, **88**, Oct., 204–206) An air conveying plant adopted by Wehr Steel Co., Milwaukee, for unloading and distributing sand binders, enabling purchase in bulk 50-t railroad hopper cars instead of in bags, with details of additional resultant labour and other economies, is briefly described.—S.H.-S.

Safe lifting gear in the foundry C. H. A. McCaully (*Engineer Foundryman*, 1960, **26**, Oct., 27–29) A general description of lifting methods including the use of special hooks, spreader bars, endless chain slings. The effect of working load and low and high temp. on the life of safety gear is examined.

Study on a hot-blast cupola J. C. Margerie and E. Tallec (*Fonderie*, 1960, Aug., 325–342) Twelve experimental melts were used in order to study the effect of blast temp. between 300°C and 650°C on carburization, loss of Si and Mn, sulphur content, and output rate. Structures and mechanical properties of the resulting iron are described. Particulars of the cupola used are given.—R.P.

Example of the behaviour of an acid hot blast cupola (*Fonderie*, 1960, June, 259–262) The influence of melt composition, blast temp., and percentage of coke on the campaign of an acid hot-blast cupola are discussed. The relationship between depth of chill, casting temperature, and carbon equivalent is outlined.

The part played by coke quality in the functioning of a cupola R. Loison, L. Soubrier, and M. Decrop (*Fonderie*, 1960, April, 121–134) Results of physico-chemical and mechanical tests on coke are discussed with a view to evaluating its influence on cupola operation. Thermal shock resistance appears to be of first importance. Results are not conclusive.

Some aspects of melting steel scrap in a cupola J. Gaertman (*Metalen*, 1960, **15**, Dec. 31, 418–426) After considering the development of melting scrap steel in cupola furnaces, the author goes on to describe the melting process with reference to carburization, sulphur absorption, and the influence of shrinkage on the mechanical properties of the steel. Illustrated with photomicrographs.—F.R.H.

A new cupola charge make-up system for LCF's shell moulding foundry C. C. Preble (*Ironworker*, 1961, **24**, (3), 8–9) The original method of making up cupola charges is briefly described. The present method involves an open leg cantilever semi-gantry capable of unloading from the railroad trucks and handling the various components involved. For metal, a low headroom 45in circular magnet is provided. With coke, this is removed and a special spreader bar is used. The batching is described. The metal components are loaded with the magnet into a weigh hopper located in the centre of a roofed storage platform; any excess is left on the platform. An operative makes any required additions and operates the discharge gate so that the charge enters a cone bottom charging bucket on a motor driven, push-button transfer car. This is then transferred into position under the coke batching monorail where the coke charge is dropped in. The car moves to the next position where miscellaneous minor components are added to the charge. The car next moves under the charging crane; the empty bucket from the previous charge is moved, being placed on the transfer car while the full bucket is picked up. The empty charging buckets are returned to the metal weigh hopper to repeat the cycle.

Physical factors affecting combustion at tuyeres G. L. Shires (*Brit. Found.*, 1960, **53**, Oct., 447–455) The penetration of air blast into the cupola fuel bed was studied by means of a two-dimensional Perspex model and a small scale combustion apparatus with a single tuyere. The ratio fuel particle size: cupola dia., tuyere inclination, and tuyere air velocity were shown to control blast penetration. A cooling effect of cold blast air on combustion at tuyere level and the dependence of the position of the maximum fuel bed temp. on tuyere air velocity were also demonstrated.—A.D.H.

A new concept in desulphurization (*Engineer Foundryman*, 1960, **26**, Sept., 32) What is claimed as the first truly continuous process of desulphurization, developed in America by the Diamond Alkali Co. of Cleveland, is illustrated and described.—S.H.-S.

Use of mains frequency furnaces in the melting of cast iron L. Mathews (*Castings*, 1960 **6**, July, 35, 37–40) There are no moving parts, maintenance costs are low, there are no electrodes, and the lining is easy to install and low in cost. The vigorous stirring action gives rapid and efficient carburization and alloy take up resulting in a very homogeneous melt with low metal loss. Chemical composition is easy to control, there is no S-pick up and max. temp. is controlled only by the refractory lining so that metal can be maintained indefinitely at a given temp. Power load is steady at all times and power cost is lower than with high-frequency and indirect arc furnaces of similar capacity. The disadvantages are that a 'slug' or 'heel' is required to start the furnace and no refining can be carried out so that melting programs must be carefully planned where large changes in analysis are involved. All charge materials must be dry.—C.V.

The use of large capacity electric induction furnaces in foundries producing commercial and special castings A. Tagliaferri (*Fonderia*, 1960, **9**, Sept., 411–416) A description of the advantages of various types of electric induction furnaces.

Pulsating gas burners heat foundry forehearths Ford Motor Co. (*Steel*, 1960, **147**, Nov. 28, 128) The operation and effects of pulsating burners using coke oven gas rated at 490 BTU, and maintaining temp. of 2600 to 2800°F in foundry forehearths with design that is claimed to make higher flame temp. possible, are presented.—S.H.-S.

Electric melting in the foundry M. Decrop (*Fonderie*, 1960, May, 175–188) A general review of the subject, giving data on nonferrous and ferrous practice. In the last-named, technical and economic data are given on the use in the iron and steel foundry of resistance, arc, and induction furnaces (11 refs).

Switch to electric melting boosts foundry Birdsboro Corp. (*Steel*, 1960, **147**, Nov. 28, 122, 124) The operation and results of electric arc furnaces in three sizes are briefly described.

Modernized steel foundry converts to electric furnace melting Birdsboro Corp. (*Foundry*, 1960, **88**, Dec., 90–93) A conversion from OH to electric furnace operation, with its results, are presented.—S.H.-S.

Some early experiences melting grey cast iron in a coreless mains frequency induction furnace L. Matthews (*Inst. Brit. Found. Aust.*, 1960, **11**, 63–70) A description is given of early production experience with the first mains frequency furnace to be installed in Australia. The cost of melting grey cast iron is compared with those recorded using an indirect arc furnace of similar capacity, and the advantages and disadvantages of mains frequency melting are summarized.—C.F.C.

Low frequency ASEA furnaces without magnetic cores B. Hanas (*J. Four. Elect.*, 1960, **68**, Nov.–Dec., 279–281, from *ASEA Rev.*, (1), 1958) The layout, and equipment of low frequency furnaces with details of starting and operation are presented, with factors leading to their adoption.—S.H.-S.

A comparative study of medium frequency and mains frequency induction melting furnaces for ferrous metals A. R. Baffrey (*Austral. Eng.*, 1960, **52**, Oct., 68–73) The correct frequency and capacity of furnace is indicated for the production of steels, cast iron, etc. Comparison is made between capital cost of crucible type induction furnaces of the two frequencies, components, and equipment being included. A simple method of comparing power costs is given. The effects of electrodynamic or stirring forces are considered and compared. Between the two types, there is a degree of overlap but there are certain spheres where each possesses special advantages.—C.V.

New induction furnaces offer composition control Hevi-Duty Electric Co. (*Steel*, 1960, **147**, Nov. 21, 112, 115) A new furnace line, with 60 cycle induction equipment, of Italian origin, offering easier control of composition, readily variable pouring temp., and simplicity in changing from one composition to another, is briefly described.—S.H.-S.

Special cast irons R. Barton (*BCIRA J.*, 1960, **8**, Nov., 857–882) High-Cr, Ni-hard, Silal, high-Si, Nicrosilal, and acicular cast irons are reviewed with notes on production and heat treatment.

Metallurgy of iron castings W. H. Moore (*Foundry*, 1960, **88**, April, 91–97) The relationship of iron and carbon, the effect of graphite, of Si, Mn, and of sulphur, with alloy effects on the matrix, and of Al additions, together with the graphitization of the melt, and the eutectic cell count, are discussed and their relative importance in cast iron metallurgy is assessed.

Inoculants for production of high-strength grey iron H. H. Wilder (*Foundry*, 1960, **88**, June, 116–119) The purpose of the treatment, the composition of types of inoculants available, the alloying elements in grey cast iron, and advice on how to use the technique successfully, are presented.—S.H.-S.

Hypoeutectic grey cast iron ladle additions D. D. McGrady, C. L. Langenberg, D. J. Harvey, and H. L. Womochel (*Mod. Castings*, 1960, **38**, Oct., 113–122) The effect of graphite, Si, Al, and Ca additions on the solidification, microstructure, and mechanical properties of these irons has been investigated.

Effect of some melting furnace atmospheres on graphitization of white iron M. Ibaraki and T. Okamoto (*Nippon Kinzoku*, 1960, **24**, (6), 351–355) A commercial iron and ore made from electrolytic Fe, graphite, and metallic Si were used. A melt was held at 1320–1330° for 30 min *in vacuo* or in A or N_2 and cast in an iron mould. Graphitization appears to be related to acid-soluble nitrogen content.

Contribution to the experimental study of grey iron with diffused temper graphite A. Vilain and A. Botte (*Revue ATB Mét.*, 1960, **2**, (1), 1–11) Graphitization phenomena were studied by dilatometry, thermal analysis, and microscopy. The influence of various factors on homogeneity and fineness of structure are investigated, and graphitization times and mechanical properties compared with those of malleable cast iron of the same composition.

Studies on the inoculation of cast iron M. Yohda, M. Hiraki, and T. Takayama (*Bull. Fac. Engng. Toyama Univ.*, 1960, **11**, March, 86–91; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1960, **7**, Nov., 427) [No abstract].—C.F.C.

Spheroidal graphite non-magnetic cast iron. Influence of different admixtures A. Méallier and J. Grilliat (*J. d'Inf. Tech. Fonderie*, 1961, (122), Jan., 1–3) The influence of Ni, Mn, Cu, Cr, etc., on non-magnetic cast irons of different types is discussed.—S.H.-S.

Pearlitic malleable iron (*Machinery*, 1961, **98**, Feb. 8, 315–318) The hardenability curve of end-quenched pearlitic malleable iron is compared very favourably with that of forged AISI 1046 steel; examples are given of clutch hubs, crankshaft sprocket, and journal bearings and crankpin and a comparison of performance and cost of gears cast in different materials (grey iron, nodular iron, and pearlitic malleable iron) is informative.—C.V.

Pearlitic malleable iron meets new industry demands C. F. Joseph (*Mod. Castings*, 1960, **38**, Oct., 37–40) The growth of pearlitic malleable iron tonnage is outlined, the importance of close chemical control is emphasized, and the advantages of B and Bi additions are given.

Pearlitic malleable meets many engineering requirements C. F. Joseph (*Mod. Castings*, 1960, **38**, Oct., 40–42) The very good machinability, excellent properties in the range 800–1200°F, and the possibility of selective hardening are discussed, and also the ways in which these properties are utilized.

Pearlitic malleable has variety of applications C. F. Joseph (*Mod. Castings*, 1960, **38**, Oct., 43–44) The precautions to be taken in use and casting of this iron are discussed, and types of machining operation available are considered.

Malleable design contest proves economy of castings (*Foundry*, 1960, **88**, July, 120) The results of the contest sponsored by the Malleable Founders Society, giving four out of five winners having conversions of their material from fabrication on a basis of 27% in average lowered part cost in production quantities, are reported.—S.H.-S.

Quality ductile iron results from good foundry control G. A. Kramer (*Iron Age*, 1960, **186**, Oct. 20, 154–155) A central control group, correlating performance data on inspection, testing, and analysis, with seven types of statistics to keep constant check on costs and govern melting facilities and procedures, is presented.—S.H.-S.

Malleable cast iron treated with calcium silicide M. Maruyama and M. Ito (*Imono*, 1960, **32**, April, 261–267) It was found that first and second stage graphitization were promoted by addition of CaSi, and graphitization could occur with as little as 0·5%Si in the iron. It was difficult to produce a white cast iron in a sand mould after the melt had been treated with calcium silicide.

Metallurgy of 13 per cent chromium steel castings J. Beech (*Foundry Trade J.*, 1960, **109**, Nov. 3, 569–575) The variables that are to be found in the production of castings are examined at all stages of manufacture and the relevant literature is reviewed. Photomicrographs prepared in the laboratories of the British Steel Castings Research Association illustrate some of the structures encountered in practice.—S.H.-S.

Sand ... and its relationship to efficient production by CO_2 and dry-sand moulding processes F. A. Butler (*Found. Trade J.*, 1961, **110**, Jan. 26, 113) Satisfaction with plant and practical hints on the operation of both CO_2 and dry-sand moulding processes making a wide range of castings are reported by a foundry manager.—S.H.-S.

Standardization of mould production S. A. Krivitskii (*Lit. Proizv.*, 1960, (8), 13–15) The reduction in the number of different operations by the maximum division of labour is at the basis of the suggestions made in this article which is a plea for standardization at all stages: blanks for the different component units and standard tolerances for moulds and castings. Tables are given with suitable classifications.

Core drying in high frequency furnaces H. C. Grassmann (*Elekrowärme*, 1960, **18**, Oct., 323–328) After briefly describing conventional methods of core-drying, the construction and operation of HF-core driers are described in detail with the necessary binders and their properties. In spite of high initial cost the advantages of operational economy of the process experienced in Germany, and the consequent reduction of foundry production costs, are outlined.—S.H.-S.

Research on plaster moulds and their hot properties C. Hisatsune and A. Shimizu (*Imono*, 1960, **32**, June, 429–437) A study on some cracks or destruction of the surface of plaster moulds during casting is described and results are given, with suggestions for the addition of cushion agents, such as asbestos, for the increase of thermal expansion of moulds.

Cores prepared with CO_2 impregnated with organic binders M. S. Razumova (*Lit. Proizv.*, 1960, (8), 45) A novel core mixture consisting of Orekhov sand with 0·5% water and 2·5–3% waterglass of sp. gr. 1·47–1·50 was impregnated in turn with 5 and 10% solutions of powdered Bakelite in acetone, waste sulphite liquor (sp. gr. 1·1) and molasses. The best results are given by the powdered Bakelite.

Studies on the fluidity of cast iron K. Takahashi and Y. Yokoi (*Imono*, 1960, **32**, June, 410–415) A test of the relation of the quality of cast irons to the fluidity and of the pouring time of the castings is described and the results presented.—S.H.-S.

Experience with the casting of steel cog wheels A. K. Ponomarev (*Lit. Proizv.*, 1960, (8), 45) The casting operation on these wheels is described. Its special feature is the provision of individual risers of an oval cross-section 20–30% larger than the thickness of the cross-section of the rim.

The technology of casting the sleeve pipes for the 2D 100 diesel motor M. S. Gvosdev (*Lit. Proizv.*, 1960, (9), 41) These sleeves are moulded in a horizontal position in a twin box. The moulding is done by a shaking machine. A detailed description is given of the entire operation.

Nozzles for sand and shot blasting machines cast into moulds V. N. Mkrtchyan and A. N. Railyan (*Lit. Proizv.*, 1960, (8), 46) This process as carried out at the Mankent repair works is here described. It results in a much better product than was obtained earlier and reduces production costs to one-fifth.

Cast reinforcements for concrete structures O. S. Rainus (*Lit. Proizv.*, 1960, (9), 41–42) These cast reinforcing frames are intended to replace the laborious work of reinforcing concrete structures. The frames are cast in sulphur iron, are 2 m in length, and are trapezoid in shape.

Casting rolls of steelmaking iron N. F. Troshin and V. K. Sotnikov (*Stal'*, 1960, (11), 1051–1052) Casting of rolls with homogeneous structure gives increased strength, lower cost per ton rolled, and reduction in wear. Carburizing the metal gives a further increase in strength.

Plastic patterns J. W. John (*Brit. Found.*, 1960, **53**, Aug., 362–369) Experiences with the development of phenol-formaldehyde resins which proved unsuitable because of dimensional instability are described. Current practice for the production of epoxy resin patterns and core boxes is reviewed.

Temporary moulds of talc-chlorite V. G. Korotkov (*Lit. Proizv.*, 1960, (9), 42) For individual small and average scale production it is advisable to use temporary moulds of cheap materials such as talc-chlorite, serpentine, ophiolite, and other minerals of laminated hydro-silicate type. The hardness of talc-chlorite is 1 and its specific gravity 2·7–2·8. The hardness of serpentine is 2·5–3·5 and its specific gravity 2·5–2·7. Both are heat resistant above 1500°. The preparation of the moulding mixture and of the mould are described.

The use of very low ratio sodium silicate in the CO_2 process leads to sand economy D. A. Taylor (*BCIRA J.*, 1960, **8**, Sept., 675–679) It is reported that by using sodium silicate with a SiO_2:Na_2O ratio of 1·6:1 it is possible to prepare satisfactory silicate/CO_2 process moulds from sands containing appreciable amounts of clay, and with higher moisture contents than otherwise permissible. Consequently, the range of base sands can be extended and the cost of the process reduced. The simplest method of application employs a mixture of about equal parts of dry, clay-bonded sand, discarded after use, and undried silica sand. Limitations of the method and precautions to be observed are given.—S.H.-S.

Some factors affecting the accuracy of investment casting Yu. P. Kondrat'ev (*Lit. Proizv.*, 1960, (8), 7–8) The linear shrinkage, the criterion for the accuracy of investment casting, is affected by the volume of air mixed with the moulding material, by the condition, temp., and pressure at which the moulding paste was compacted, by the time the paste was under pressure and the temp. of the mould during filling with metal. These factors are analysed separately and graphs showing their effect on the total shrinkage are given.

New technology for firing investment-casting moulds I. B. Sokol, B. A. Pepelin, and V. I. Rutkovskii (*Lit. Proizv.*, 1960, (8), 4–6) The ceramic mould made with ethyl silicate, powdered quartz, and sand consists, after firing, essentially of SiO_2 (67% powdered materials, 28% filling, and 5% binder). The normal firing of these ceramic moulds in electric furnaces takes 30–40 min and 5% of the moulds develop cracks. In transit to the pouring machine these moulds, heated to 850° are prone to crumble because of rapid cooling in air. The new method expedites the process of firing and reduces cracking to a minimum. The moulds are introduced into a small 'Coleman' furnace with one gas burner and the firing time is 5–8 min. The moulds do not crack because of the uniform heating of the ceramic coating which is surrounded by the burning gases.

Cooling rate of thick-walled cylinders Z. V. Kovalevskaya, P. F. Karandashov, and V. P. Kachanov (*Stal'*, 1960, (11), 1038–1041) 38 KhN4MF steel was used 170–200 mm thick and the results can be applied to calculate cooling rates in water of the cores of large objects.

The effect of the technological factors on residual stresses in castings and on the force required for removing metallic cores V. S. Lovchikov (*Lit. Proizv.*, 1960, (8), 41–44) The effect on the residual stresses of the period during which the core is in the casting is given in a table. These stresses diminish with an increase in this time interval. The temp. of the metal mould also exerts an appreciable effect on the quality of the castings. A reduction in this temp. brings about an increase in the residual stresses and may cause cracks. The temp. of the liquid metal also influences residual stresses. The compressive stresses on metal cores increase the force necessary for knocking out. These compressions arise from the shrinkage and heat expansion of the core, and increase with time.

Grey and white solidification of cast iron M. Hillert (*ASM preprint No.*216, 1960, 555–567; also in *Met. Prog.*, 1960, **78**, Oct., 210, 212, 214, 216) The theory explaining inverse greyness or inverse chill in terms of variations in cooling rate is discussed and shown to require modifications and considered in terms of nucleation

of graphite and cementite. Grey and white solidification are further discussed as well as cooling rate effects and the action of Si.

The effect of the duration of pouring on the resistance of steel in the course of solidification to cracking V. N. Saveiko (*Lit. Proizv.*, 1960, (8), 33–36) Tests have shown that pouring should be carried out differentially; the resistance of steel to crack formation is increased by a reduction in the time of pouring into the section of the casting normally subject to cracking and by increasing the time of pouring into thick sections of the casting. In all cases, pouring temp. should be the lowest possible so that the metal temp. in the various portions of the castings approaches the liquidus temp.

How to avoid hot tears in steel castings M. A. Notte (*Metalw. Prod.*, 1960, **104,** June 8, 61–63) Reasons for hot tears (which form when part of the metal is still in a liquid state, with tensile strength and ductility nil) are described, with a choice of remedies. A series of design data for castings, illustrating danger points, are shown.—S.H.-S.

Sand control H. E. Henderson (*Foundry*, 1960, **88,** July, 153–156) The need for persistence in the maintenance of improved quality control, and for setting sights on more distant and more difficult targets is stressed.—S.H.-S.

Is a new concept needed for hot sand properties? G. J. Vingas and A. H. Zrimsek (*Mod. Castings*, 1960, **38,** Nov., 33–35) The inadequacy of present tests is underlined, and it is suggested that a complete rethink on this question is needed.

Close moisture control improves moulding sand R. H. Herrmann (*Foundry*, 1960, **88,** June, 164, 169) The operation and control of a system comprising seven moulding lines, each line holding 100 tons of sand with a consumption of that amount three times hourly is described with brief data on automatic control of moisture (deviation being one-fourth of that under manual control) and provision for variations in mixes.—S.H.-S.

Characteristics of foundry sands W. P. Winter (*Foundry*, 1960, **88,** Dec., 79–81) In the second of a series of six articles on sand topics, some of the items covered include availability, cost, stability, density, and melting point. The properties of silica, olivine, zircon, carbon, chamotte, and mullite sands are tabulated and evaluated.—S.H.-S.

Moulding sand practice in Australia H. A. Stephens (*Inst. Brit. Found. Aust.*, 1960, **11,** 5–41) The Australian foundry industry began shortly after the arrival of white settlers in the continent in 1788 and now caters for the needs of a population of 10 million. Castings up to 50 t in steel and up to 10 t in bronze can be made. The foundry-sand resources of the various states are surveyed and the availability of other moulding materials is described. Moulding-sand practices are adapted to meet local conditions and the wide range of foundry equipment used is outlined.—C.F.C.

Sand angularity and shape factors G. J. Vingas and A. H. Zrimsek (*Mod. Castings*, 1960, **38,** Oct., 73–82) Theoretical concepts for describing shapes, sharp corners, edges, and surfaces of foundry sands by numbers and ratios of surface area to volume are comprehensive but limited. The microscope still remains the only tool capable of assessing relative shape.

Systematic approach to sand design and control A. H. Zrimsek and G. J. Vingas (*Mod. Castings*, 1961, **39,** Jan., 85–92) This is the second in a series of reports presenting basic data describing the effect of a number of variables on foundry sands. The dry properties of clay–sand–water combinations are covered here. Western and southern bentonite and fireclay were used in the work. **Progress rept. III. The mulling effect** (Feb., 93–109) This report deals with the effect of mulling time and method of additions to a sand–clay–water system in relation to green compression strength, ratio of green compression strength to green shear strength, density, dry compression strength, and dry shear strength. The clays investigated are western and southern bentonite and fireclay.

New sand practices produce five-way profits W. D. McMillan (*Mod. Castings*, 1961, **39,** Feb., 33–35) By using a sand mix of olivine flour, silica sand, and an air-setting binder, savings in draft, drying, and grinding result, while an improved yield (casting weight to melted metal is 58%) and an improved surface finish are obtained.

Steel foundry sand clay bonding J. B. Caine, E. H. King, and J. S. Schumacher (*Mod. Castings*, 1961, **39,** Jan., 111–116) Doubt is cast on accepted theories of 'clay film thickness' and 'clay distribution' by mulling, as a result of this microscopical study of steel foundry sands.

Specific-surface and grain-structure of foundry sands F. Hofmann (*Found. Trade J.*, 1961, **110,** Jan. 12, 45–47; from *Giesserei*, 1960, **47,** 49–56) A method of finding the actual specific surface is described and used in conjunction with sieve analysis to evaluate an important property of foundry sands. An experimental procedure demonstrating a correlation between two characteristics of separate grains, likely to be of practical importance to founders, is presented.—S.H.-S.

Cold setting oil sand: its solidifying mechanism under room temperatures T. Kawada, U. Uegaki, and S. Horii (*Mitsui Tech. Rev.*, 1960, July, 18–21; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1960, **7,** Nov., 397) [No abstract].

On the falling of moulding sand. (1) The phenomenon of 'vena contracta' S. Hori and Y. Yuasa (*Res. Rep. Kogakuin Univ.*, 1960, May, 155–160; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1960, **7,** Nov., 397) [No abstract].

Burning of silica sands for steel casting Y. Yoshikawa (*Railw. Tech. Res. Rep.*, 1960, July, pp.87; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1960, **7,** Nov., 396) The relation of sand adhesion to the grain size. ramming hardness, and 'washing' by molten steel, of silica sand was investigated on test castings. In order to clarify the essential nature of sand adhesion, the reaction at the metal–sand interface was observed in a laboratory experiment, the effect of wash was studied by applying different test washes on the actual sand mould.

Effect of ferrous oxide on zircon sand at 1200°C R. G. Wells, L. H. van Vlack, and R. Lalonde (*Amer. Ceram. Soc. Bull.*, 1960, **39,** Dec., 735–739) It is shown that at this temp. there are three compatibility triangles in this ternary system; fayalite, tridymite, and zircon, fayalite, baddeleyite, and zircon, and fayalite, baddeleyite, and wüstite, and the significance of these findings is discussed. The most important observation is the dissociation of zircon in the presence of FeO which at this temp. will result in the formation of fayalite, or an Fe-rich silicate liquid; the amount of this that forms will be similar to that formed by FeO in Si-sands, and this will result in the formation of a smooth sinter layer at the casting surface and mould interface.—C.V.

Use cement bonded sand to increase production H. Giese (*Mod. Castings*, 1960, **38,** Dec., 39–41) The way in which the process is used in an East German foundry producing mainly medium and large castings is described. About 60% of all output, 80% of sweep work, and 90% of cores are now done in this way.

Determination of true clay and its effect on sand control at D.E.W. D. R. Phillips (*Can. Metalw.*, 1960, **23,** Oct., 79–81) A paper by the Chief Chemist of Dominion Engineering Works describes the method used there to control and determine true clay content and other particle sizes. Procedure and results are reported.

Punched cards control automatic sand system L. Walter (*Foundry*, 1961, **89,** Jan., 65–67) Automatic core sand preparation, controlled by punched cards, producing one ton of core sand every 3 min at Ford's Dagenham foundry, is described and illustrated.—S.H.-S.

Physical and chemical conditions. Variation effect on bentonite suspension properties A. J. Anderson and G. J. Sutton (*Mod. Castings*, 1960, **38,** Nov., 88–97) The results of an investigation into the effect on Bingham yield value and pH of bentonite suspensions caused by the addition of reagents, some of which resemble those that could occur under natural conditions.

Hot core box design and engineering E. E. Harkness (*Mod. Castings*, 1961, **39,** Feb., 115–120) A description of equipment and processes in the foundries of the author's company, dealing with the use of faster setting binders composed of various combinations of urea and formaldehyde-furfural and single-stage phenolic resins. The hot core box process seems to offer the advantages of increased productivity and material cost reduction.

Increase of productivity by the use of progressive technologies with older pattern plates F. Werner (*Giessereitechnik*, 1960, **6,** Sept., 269–274) Several examples are described and illustrated, showing methods of utilizing materials to better advantage by increasing yields.

Engineered construction—answer to durable wood patterns W. H. Siebert (*Mod. Castings*, 1960, **38,** Oct., 60) A good pattern is the end-product of co-operation between moulder, coremaker, patternmaker, and customer. A few suggestions for design of patterns are given.

New materials for wood patternmaking R. LeMaster (*Mod. Castings*, 1960, **38,** Dec., 53–55) The advantages and disadvantages of a carvable epoxy material, which is available in plank or paste form, are given.

Foundry sand testing and casting defects P. H. Riley (*Engineer Foundryman*, 1960, **25,** Feb., 28–34) The aim of this paper is to deal with the types of defect which can be avoided by the modification of foundry sand mixtures as a result of the correct interpretation of the results of sand testing. The simplicity of the routine tests are described and point out that the most expensive form of testing sand is to cast metal into it.

Sand flow speeded by resin coating of hoppers A. W. Johnson (*Foundry*, 1960, **88,** Oct., 166–168) A brief report on results of tests described after applying epoxy resin coatings to 24 l-t steel moulding station hoppers which reduced the sand-sticking problem by 95%.—S.H.-S.

Making reversible pattern plates (*J. d'Inf. Tech. Indus. Fonderie*, 1960, Sept., (119), 3–5) A short descriptive account, with 13 sketches, of two methods of mounting symmetrical patterns on bottom plates.—S.H.-S.

Selection of timber for pattern making S. Jane (*Engineer Foundryman*, 1960, **26,** Oct., 21–22) An account of the best timber for pattern making and the factors influencing selection.

A new method of mould assembly V. Otáhal and J. Kolařík (*Slévárenství*, 1960, **8,** (9), 308–313) The introduction of cores into moulds as core-assemblies, in which individual cores are joined together by tie-rods or adhesives, is shown to be an economical method in the modern foundry. Examples of the utilization of the method in Czechoslovakia in the production of complex castings are given.—P.F.

On the production of moulds under higher pressures J. Dlezek (*Slévárenství*, 1960, **8,** (10), 341–347) The flow and deformation of typical mould mixtures subject to pressure was studied, and optimum moisture contents and other parameters desirable in mixtures used for moulding under high pressures were determined. Graphical relations facilitating the evaluation of mould porosity and the approximate surface roughness of grey cast-iron castings cast in such moulds are given.—P.F.

Risering of steel castings H. F. Bishop (*Foundry*, 1960, **88,** Oct., 114–115) A third and last article on risering steel discusses the applications and advantages of exothermic materials and knock-off cores.—S.H.-S.

Determination of feeder sections for parts of any size and shape, for all metals and alloys, cast in all types of sand C. Trenckle (*Fonderie*, 1960, April, 135–156) The principles underlying the calculation of feeder and runner sections for various sand-casting methods are discussed. The application of this method of calculation is shown by means of seven examples.—R.P.

A foundry without moulding boxes J. Steele (*Found. Trade J.*, 1960, **109,** Oct. 20, 489–490) Wooden frames are used to retain CO_2-process moulds prior to gassing; thereafter the mould halves are sufficiently strong to permit casting-up without the need for boxes. Reinforcement is used only for large moulds. The heaviest casting made by the company to date in a boxless mould weighed 10 cwt as cast, the mould measuring 4 ft × 3 ft 6 in × 3 ft. With greater weights, boxes are used.—C.V.

Mechanized high-speed mold drying W. D. Huskonen (*Foundry*, 1960, **88**, Oct., 154–155) Twice the production on the same floor space, achieved by the installation of two mould drying ovens in the foundry of Elyria Foundry Divn. of Chromalloy Corp., Elyria, Ohio, for grey castings weighing up to 1½ t, with its equipment and operation, is described.

New core making facilities at Radford R. E. Fitz (*Ironworker*, 1960, **24**, No.3, 12–14) The facilities had to be capable of dealing with large, complex designs requiring intricate core work as well as those calling for high production rates. The attainment of this compromise is briefly outlined.—C.V.

CO_2 versus dry sand H. A. Godwin (*Engineer Foundryman*, 1959, **25**, Dec., 51–52) A discussion. Experience was gained on light castings up to 1000 lb the CO_2 being used as a facing sand ramming up a green backing sand; the mould was cast the same day. Other examples are given and it would appear that with adequate knowledge and care very satisfactory castings result.—C.V.

Studies regarding the possibility of using less gas in the sodium silicate–carbon dioxide process M. Jeancolas and X. Virolle (*Fonderie*, 1960, June, 239–251) Tests are described in order to find the minimum amount of CO_2 required to achieve efficient sand hardness. Investigation of variables showed the ratio of silica to 'Na_2O' and their concentration to be of importance. In conclusion it is stated that the quantity of CO_2 can be reduced from 4% to 1% by weight referred to sand (31 refs).—R.P.

Large, intricate investment castings now feasible: New mould process makes possible castings weighing up to 100 lb (*Mat. Design Eng.*, 1960, **52**, Sept., 11) A ceramic shell process is used; this can turn out intricately shaped castings. Previously a solid mould had to be used and this was severely limited in size. Virtually all castable alloys can be used and tolerances are maintained. The lightweight shell essentially enables this to be achieved; it is made by dipping a wax pattern repeatedly into a ceramic slurry so as to build up the shell and this is fired to melt out the wax and strengthen it. Apart from the increase in size and weight this process can produce parts with more intricate coring, shapes that cannot be produced by any other method and structures of fine grain structure while it is found that less finishing is required than with the normal solid mould castings.—C.V.

Production and application of ceramic mould castings L. W. Dean (*Foundry*, 1960, **88**, Oct., 142–146) A ceramic moulding process is described which can be used to make both moulds and cores for either ferrous or nonferrous castings up to 350 lb with close tolerances but without high tooling costs, good surface finish, and thin walls being also obtainable. Various special applications are cited.—S.H.-S.

Shell cores—why and how they are used (*Foundry*, 1960, **88**, Oct., 92–105) A special report summarizes the current status of shell coremaking in America in 1959 as 986 foundries having 1759 shell core machines, against 553 foundries having 936 shell mould machines. Advantages for shell core use are cited, and are supplemented by six special articles describing the operating experiences of six plants with their respective reasons for adopting shell cores.

Production and properties of cast iron bar J. Cumberland (*Found. Trade J.*, 1960, **109**, Oct. 27, 523–533) Static graphite-dies are briefly discussed. Melting is carried out in a conventional acid-lined cupola of 2 t/h melting capacity and a close grained, readily machinable, grey cast iron bar is obtained. Vertical and horizontal continuous casting machines are discussed, the former being simpler to operate for smaller sizes of bars. The applications for cast iron stick are reviewed, special mention being made of the glass bottle industry.—C.V.

Mould paints and washes for steelfoundry use J. M. Middleton and P. G. McIlroy (*Brit. Found.*, 1960, **53**, Oct., 429–439) The influence of clay additions, properties of the underlying sand, heating rate, and the density and composition of mould washes on their cracking and effect in preventing metal penetration and improving surface finish. Only thick coatings of paints containing highly refractory materials prevent penetration under high ferrostatic pressures.—A.D.H.

Pouring cast-iron fly-wheels (*J. d'Inf. Tech. Indus. Fonderie*, 1960, Sept., 1–2) Two methods of casting flywheels, of 70 kg in lots of 200 are described, the first method in a sloping and the second in a horizontal position. The second method is recommended as giving castings of more even mass and better equilibrium.

On the production of shapes from special steels of low forgeability Z. Eminger and V. Paur (*Hutn. Listy*, 1960, **15**, (9), 705–710) Several examples are discussed in which casting to the approximate shape, followed by a minimum amount of forging, facilitates the production of components, e.g. turbine blades, from steels of low forgeability.—P.P.

Use of pits to mould large castings F. Gale (*Can. Metalw.*, 1960, **23**, Sept., 37–40) A general illustrated description.—C.V.

Iron moulds for centrifugal casting J. W. Cherrett (*Can. Metalw.*, 1960, **23**, Aug., 49–51) Centrifugal casting in moulds with graphite or sand linings is compared with casting in steel or iron moulds where the metal, except for the mould dressing, is directly against the mould walls. This latter gives the best results, the moulds being made of heat-resistant alloys. Mould life can be extended by water spraying the exterior while the casting is being poured. This technique is used with horizontal casting machines. Technical details are given.—C.V.

Gating steel castings. I C. W. Briggs (*Foundry*, 1960, **88**, June, 124–127) The first of two articles on the gating of steel castings describes the importance of the down gate and the distribution system. Causes of mould erosion, and how to avoid it, the effect of gating on porosity, and the effects of gas on mould surface and methods for its removal are discussed. **II** (July, 86–91) The concluding article discusses metal cleaning devices and factors which determine size, shape, and placement of gates, with a summary emphasizing the effect of design, application, and care given to construction of the gating system on the quality of steel castings and their solidification, and its responsibility for the presence or absence of a variety of defects.—S.H.-S.

Gating malleable iron castings H. J. Heine (*Foundry*, 1960, **88**, Dec., 68–73) The factors to be considered in the design of gating systems for malleable iron castings, including pearlitic malleable, are presented and discussed with an allusion to the use of moulded rubber sprue cups now adopted in many foundries.—S.H.-S.

Risering of malleable iron H. J. Heine and R. A. Peacock (*Foundry*, 1961, **89**, Jan., 82–89) Functions of risers for malleable iron castings, including shapes, sizes, locations, and other factors, are discussed, with supporting mathematical data.—S.H.-S.

Increases yield by using hollow sprues R. H. Herrmann (*Foundry*, 1961, **89**, Jan., 58–61) A hollow sprue in place of the conventional solid sprue is described which is claimed to have increased casting yield as much as 300%.

Rapid setting mould mixtures on dextrin, dextrin-sulphite waste liquor and waterglass-dextrin bases A. Gebauer (*Giessereitechnik*, 1960, **6**, Sept., 280–281) The properties and notes on the application of these mixtures are given.

New furfural binders reduce core cost International Harvester Co. (*Mod. Castings*, 1961, **39**, Jan., 31–33) These new binders cost less for materials, and harden more quickly than shell cores. The chemistry, mixing, blowing, and use of the material are described.

Pressure drying of moulds by electricity W. Annen (*Found. Trade J.*, 1961, **110**, Jan. 26, 107–111) An experimental study of the relative efficiency of electricity and coke for drying moulds is presented. The principal methods for drying sand moulds to receive steel and grey iron are briefly described, and measurements quoted for drying by electrical means. Characteristics common to mould drying generally, and particularly to pressure drying, are discussed.—S.H.-S.

Economy with the CO_2 process D. J. Cousins (*Found. Trade J.*, 1961, **110**, Jan. 19, 79–80) By the control of moisture and following a new milling technique an investigation and its results are described showing how reclaimed sand may be employed successfully in the CO_2 process.—S.H.-S.

Big investment castings: I H. Lefer (*Prec. Met. Mold.*, 1960, **18**, Nov., 54–55) A general description of the ceramic shell process with illustrations of parts produced.

Some experiences in the manufacture of cast austenitic manganese steel trackwork P. Emmerson, J. C. Nicholson, R. Anderson, and P. Dunn (*Inst. Brit. Found. Aust.*, 1960, **11**, 71–85) Tramway crossings and intersection castings reviewed and methods of production are described.

The production of ribbed tubes for recuperators L. Bohaček (*Slévárenství*, 1960, **8**, (12), 429–430) An improved process in which the tubes are cast in one piece, rather than in two halves, which had to be welded, is described.

Aircraft-missile steel castings S. A. McCarthy (*Mod. Castings*, 1961, **39**, Feb., 110–114) The importance of co-operation between caster and designer is stressed, and the modification of casting techniques in this light is discussed.

Varieties of heat resisting castings T. Momose, T. Izu, and A. Yoshida (*Imono*, 1960, **32**, April, 251–260) The resistance to growth and scaling, and the tensile properties at elevated temp. of three groups of cast iron; (1) low Cr, low Ni–Cr, high Si–Al, and ordinary ductile cast iron. (2) High Si ductile and low Cu cast iron, low Cr, and low Al–Cr cast iron. (3) Hot dip aluminized or calorized low Cr and low Al–Cr cast iron. The maximum allowable temp. were decided from the results.

The mechanical restraint of shrinkage in castings made in metallic moulds V. N. Razumov (*Eng. Dig.*, 1960, **21**, Nov., 81–84 from *Lit. Proizv.*, 1960, (8), 36–40).

Casting in rotating moulds L. Orsini (*Fonderia*, 1960, **9**, Sept., 417–419) A description is given of the new centrifugal casting process with details of the materials and the properties acquired during centrifugal melting.

Shell moulding in the Csepel steel and iron foundry O. Racs and L. Kalman (*Fond. Ital.*, 1960, **9**, (10), 397–402) The writers describe the development of the shell moulding process in the Csepel works, Budapest which has achieved notable economies. Cylinders from 125 to 250 cm are produced and also cores for chain rings and white and grey iron castings. The most important factor in future expansion will be the increase in productivity by the introduction of the new pneumatic process. The production of shell moulding sands which will facilitate mass production will also be important.

Mechanical resistance of shell moulds, at casting temperature J. Szekeres (*Fond. Ital.*, 1960, **9**, (10), 403–406) Tests for determining resistance are described. The influence of the hardening agent, the thickness of the shells and the effects of additions on resistance to both high and low temp. are dealt with.

The use of cement in investment casting J. Hockin (*Brit. Found.*, 1960, **53**, (10), Oct., 442–447) Satisfactory investment castings can be produced if the mould has an adequate green strength. The effect of mould materials, the preparation of the mixture containing cement and the preparation of the mould from this material on green strength were investigated. Vibrated moulds containing aluminous cement made with the minimum of water were best.—A.D.H.

Study of the cooling of liquid cast iron in ladles M. Decrop and J. P. Aymard (*Fonderie*, 1960, Sept., 359–370) Theoretical and practical aspects of solidification of melts in ladles are discussed. Experimental details of the investigation are given. Data for a 30 kg and a 300 kg ladle are appended.—R.P.

Drying and pre-heating foundry ladles G. Holmes and K. G. Rhodes (*Gas World*, 1960, **152**, Aug. 20, *Industr. Com. Gas*, **42**, (2), 34–36) The necessity for, and development of ladle drying is briefly reviewed; heating being carried out to 500°; the life and re-lining of ladles are also outlined. Ladle drying units capable of heating ½–20-t capacity ladles to 800° in 50 min were produced and two units for drying ladles up to 60 t-capacity are noted.

HEAT TREATMENT AND HEAT-TREATMENT FURNACES

Distortion in heat treatment—its cause and prevention W. Anderson (*Met. Prog.*, 1960, **77**, June, 120–121) The incidence of distortion in heating, holding at temp., and cooling, and methods by which it can be reduced or prevented, are discussed.

Heat treatment practice in relation to the dimensional stability of steel N. J. Sheppard (*Trans. Austral. Inst. Met.*, 1954 and 1955, **7–8**, 293–303) Design and type of material are the most important of a large number of factors influencing distortion during treatment. Case hardening, nitriding, and induction hardening are also considered and retained austenite and its local transformation, as by grinding, is also referred to (48 refs).

Electric bell furnaces for heat-treating stainless steels Shepcote Lane Rolling Mills Ltd (*Wild–Barfield J.*, 1960, **7**, Dec., 10–12) A new installation is described consisting of four electrically-heated bell furnaces of the lift-off type; these were supplied with two charge bases, a slow-cooling hood, and automatic temp. control equipment. The furnace casing and hoisting mechanism is described together with the heating and circulating system so that uniform thermal conditions are attained. Two furnaces taking coil loads of 10 and 15 t are also briefly discussed. Instrumentation includes Kent controllers and Kent three-point recording instruments giving a positive check of the thermal conditions on any of the bases and on the heating bells themselves.—C.V.

Flames and furnaces M. W. Thring (*Iron Steel*, 1960, **33**, Oct., 514–517, 520) The combustion of liquid fuels is considered. The burning of a premixed fuel vapour with air is examined in this section.

Effect of carbide stringers on the distortion of die steels during heat treatment K. Sachs (*Met. Treatment*, 1960, **27**, Oct., 395–400, 408) The author points out the importance of reducing distortion of tool steel for reasons such as mass production and the use of interchangeable components which require close accuracy. The author then lists the causes of distortion and deals with them by means of spring models representing internal stresses.—A.H.M.

Improved processing line increases plate output (*Steel*, 1960, **147**, Sept. 26, 114) A new plate heat treating line, claimed to increase production of T-1 steel and armour plate at the Homestead (Pa.) works of United States Steel Corp. processes carbon and alloy steel plates up to 45 ft long, 156 in wide, and 2 in thick, comprising a hardening furnace, a tempering furnace, and a pressure quench. Operational details in comparison with preceding Drever installation at the plant are given. One operator, using pushbutton controls and a television monitoring system, handles the processing line.—S.H.-S.

Hardening shop technology W. Stuhlmann (*VDIZ*, 1960, **102**, Aug. 21, 1161–1163) A review of recent literature on various aspects of hardening and the mechanization and automation of hardening techniques (44 refs).

Cementation of stainless chromium steels N. F. Vyaznikov, S. S. Ermakov, and N. N. Soldatova (*Metalloved. Term. Obra. Met.*, 1960, (3), 11–13) In order to increase the surface hardness of components from 1Kh13 and 1Kh17 steel experiments were carried out to evolve a cementation and hardening method. These trials are described and the findings tabulated. It appears that to obtain a tough core with a hard surface for stainless steel components they should be tempered at 550° after cementation and hardening.

Cementation of stainless steels A. G. Andreeva and A. P. Gulyaev (*Metalloved. Term. Obra. Met.*, 1960, (3), 7–11) To obtain a cemented layer of great hardness it is necessary to obtain saturation, with above 2% carbon. The process must be carried out either at 950 or at 1000° for 15 or 5 h respectively so as to obtain a layer of a total depth of 1·1·2 mm. The thickness of the layer of 58 RC hardness depends on the conditions of the subsequent thermal treatment. The optimum conditions are quenching from 1000°, cold treatment at −70°, and tempering at 160° or 500°.

The distribution of carbon in the cemented skin of alloy steels A. P. Gulyaev and V. D. Zelenova (*Metallov. Term. Obra. Met.*, 1960, (3), 2–7) A chemical analysis of the cemented steel, layer by layer, will give an average carbon content in a layer without its distribution between phases. An X-ray analysis makes it possible to determine the carbon content in austenite (or martensite) and a comparison of these two analyses will give an idea of the distribution of carbon in the carbide phase. Thus two types of carbon distribution have been revealed, a normal type in which the concentration of carbon in the cemented layer is at a maximum at the surface and gradually diminishes in depth, such as in type 20, Kh13, and Kh17 steels, and an abnormal concentration in which the maximum is reached at some depth below the surface of the cemented layer, as for example in steel 18KhGT and in other low-alloy cemented steels.

Heat treatment of Mn–V–Mo age-hardening austenitic steel N. C. Howells and E. A. Lange (*NRL rept.* 5464; *PB* 161370, 1960, May, pp.10; from *US Res. Rep.*, 1960, **34**, Sept. 16, 326) The age-hardening characteristics of Mn–V–Mo austenitic steels have been determined as a function of the temp. of the solution treatment. The optimum condition for developing the full age-hardening potential of an alloy is ½ h at 2100°F followed by a water quench. Subsequent ageing treatments required for maximum-hardness levels are: 1 h at 1400°F, 6 h at 1300°F, or 16 h at 1200°F. An ageing temp. between 1200°F and 1300°F is optimum for controlling the balance between yield strength and ductility. The yield strength of metals in the fully-aged condition is directly proportional to Brinell hardness, ranging from 80000 to 150000 psi for the compositions investigated.—C.F.C.

Heat treatment of the cutting tools made from U10 and U12 steels A. A. Matavin (*Metalloved. Term. Obra. Met.*, 1960, (7), 57) A schedule has been worked out giving a hardness not less than HRC 65–67. The cutting tools after mechanical treatment, including grinding, are quenched in brine (8%) and soda ash (2%) at 16–18° with subsequent final cooling in oil. Heating should be at 820–830°. Induction heating by high-frequency currents is carried out in a circular two-coil inductor with a 10 mm gap between the inductors and the tools to prevent burning. After hardening, the tool is tempered at low heat, 110–120° for 2–4 h.

Improving the plasticity of the textured silicon steel Ya. S. Shvartsbart (*Metalloved. Term. Obra. Met.*, 1960, (2), 11–13) The material investigated was textured silicon iron (cold-rolled transformer steel) for screening main cable junctions and wound magnetic circuits, which requires improved plasticity. The schedule for heat treatment as worked out at the 'Elektrostal' ' works is explained. Best results have been shown by a hardening from 800° which has given most bendings. When heating below or above this limit coarse segregations of the carbide phase remain in the grain boundaries.

The effect of the heating time during hardening on the structure and properties of high speed steel E. A. Smol'nikov (*Metalloved. Term. Obra. Met.*, 1960, (3), 41–47) In the process of heating components of high speed steels for hardening, the saturation of the solid solution with carbon and alloy elements is not completed with their heating. The saturation of the austenite proceeds for some further time interval determined by the original microstructure and the selected hardening temperature. The holding time after heating, necessary to complete the principal stage of the conversion of the carbides to solid solution is: for R 18 steel, from 1275°, 1·16 min and for R 9 steel from 1230°, 0·6 min. A further increase in holding time is not useful because it is accompanied by grain growth and by undesirable changes of form, size, and distribution of carbides, resulting in a reduction of the mechanical properties.

The kinetics of dispersion hardening of annealed technical iron V. S. Mes'kin, R. I. Mishkevich, A. A. Alalykina, and Yu. I. Belyaeva (*Metalloved. Term. Obra. Met.*, 1960, (2), 2–6) Annealed rimming technical iron, even after slow cooling to room temp. is subject to dispersion hardening (thermal ageing). After holding 20000 h at room temp. or 300 h at 150° the coercive force increases by a factor of almost 2. Heating the annealed iron at 350° reduces the coercive force to its original value because of the coalescence of the segregating particles. However, and especially with long heating periods, partial reverse solution of the phases takes place so that another heating (50 h at 150°) again increases the coercive force. The segregation and solution of the phases in annealed iron occur more intensely at grain boundaries (in the intercrystalline layer).

Scientific basis of heat-treatment of steels in relation to practical methods A. Constant (*Bull. Cercle Etudes Met.*, 1960, **8**, Dec., 137–180) This study is divided into several main sections—a study of the transformation curves of austenite, practical methods of applying transformation curves and the behaviour of residual austenite. It is concluded that although there may seem to be different problems involved in heat-treating a large forging compared with a small piece of, say 20 grams, the same basic principles apply in both cases for the correct application of heat-treatment.

Here's where ausforming stands to-day D. V. Gullotti (*Mat. Design. Eng.*, 1960, **52**, Sept., 16–18) A diagram is provided showing the schematic isothermal transformation in the sequence of operations in ausforming and conventional heat-treatment; another deals with the mechanical properties of D6A steel, the two operations being compared. A table is also included showing the properties of D6A, 4340, V48, V63, Halcomb 218, LaBelle HT, and super Tricent steels comparing two processes, tensile strength, yield strength, and elongation being recorded. With the two former characteristics a marked improvement results with ausforming; in ductility, some steels show an improvement while in others, ductility decreases. Although deformation texture is not normally found in hot working steel, it has recently been demonstrated that this type of preferred orientation can be achieved after ausforming, although later examination showed that the effect on mechanical properties in longitudinal and transverse directions was not significant. This question is examined in some detail. The necessity for further experimental and theoretical work is stressed.—C.V.

The effect of repeated heating on microstructure and mechanical properties of 08 steel D. I. Makeev (*Izvest. VUZ Chern. Met.*, 1960, (2), 157–162) Repeated heating to 950° with subsequent cooling in air improves the structure and the mechanical properties of 08 steel, in particular, it increases its plasticity over the cross-section. The highest indices, within the limits of proportionality and yield point are obtained with repeated heating to 850° when the yield point in the longitudinal direction increases from 19 to 22 kg/mm² and the impact strength from 19 to 32 kgm/cm².

Contribution to the low-temperature treatment of hardened steel F. Erdmann-Jesnitzer (*Härt. Techn. Mitt.*, 1960, **15**, Oct., 128–133) Isothermal low-temp. treatments of a low-alloy carbon steel are discussed in relation to resulting bonding strength. A final, constant state is arrived at after 30 min treatment for any given temp. The bending strength of the steel is shown to decrease as a result of the decomposition of residual austenite.—R.F.

Sub-zeroing as an aid to the manufacturer Farnell Instruments Ltd (*Engineering*, 1960, **190**, Sept. 9, 350–351) Greater homogeneity in steels, light alloys, and rubbers can be attained by soaking at sub-zero temp. Shrink-fit methods and dehydration of aircraft instruments are especially discussed.

General metallurgical problems in the motor industry R. J. Brown (*J. B'ham. Met. Soc.*, 1960, **40**, Dec., 75–86) A review of heat-treatment, corrosion and wear, plating and fatigue effects.—C.V.

A fully automatic heat-treatment line Timken (British) Ltd (*Gas World*, 1960, **152**, Aug. 20, *Industr. Com. Gas*, **42**, (2), 32–33) A furnace installed at British Timken's is described which performs the following processes: gas carburizing, sub-critical annealing, hardening, and tempering. By the correct selection of

quenching operations with this continuous installation of atmosphere furnaces, formation of scale on the components during heat-treatment is minimized and since washing, rinsing, and drying operations are incorporated, degreasing is avoided. The supply of quenching oil and fume extraction is also discussed.

Fully automatic heat-treatment line Timken Roller Bearing Co. (*Process Control Autom.*, 1960, **7**, Sept., 439–440) A completely automatic heat-treatment line for carburizing, annealing, hardening, and tempering, performed in automatic sequence by four Birlec furnaces for treating tapered roller bearing cups and cones for vacuum brake rolling stock is described in some detail.—S.H.-S.

High temperature carburizing T. W. Ruffle (*Metallurgia*, 1960, **62**, Nov., 183–186) Equipment required for gas carburizing at temps. of 1000°C and above, and the means of controlling carburizing temp. are discussed, and some trial results are reported of a series of runs made at 1035°C.

On the structure of the temperature region during flame-hardening K. Falkenmeyer (*Härt. Techn. Mitt.*, 1960, **15**, Oct., 155–160) The purposes of flame-hardening are summarized. This is followed by a discussion of the influence of variables, e.g. heating rate, type of burner, gas composition, thermal conductivity, on the structure of the temp. region during flame hardening (19 refs).—R.P.

Hardenability tests as a means of laying down conditions for flame-hardening H. W. Grönegress (*Härt. Techn. Mitt.*, 1960, **15**, Oct., 165–173) A critical review of hardenability tests is given, followed by a description of testing apparatus and methods. The influence of variables on the quench test is discussed. The end quench test is considered to be suitable for predicting results of heat-treatment in general and of surface hardening in particular (11 refs).—R.P.

High frequency induction hardening of low carbon steels H. Nishimura, S. Yamazaki, K. Fujii, and O. Kyotani (*Suiyokwai-Shi*, 1959, **13**, Aug., 775–780) Steels with 0·05–0·3%C were surface induction hardened and the relation of hardness to depth measured. A second maximum appeared on this curve. It was less distinct with >0·3%C.

Induction hardening and brazing machines in automotive engineering E. Höhne (*Europäischer Maschinen Markt.*, 1960, **10**, Dec., 18–20) [In English] The increasing use of induction hardening and brazing is shown to be due to their ability to cut processing time and facilitate automation. Further advantages and future possibilities of these methods are discussed with special reference to the car industry.—R.P.

Conditions for the induction treatment of high-speed steels I. N. Kidin (*Izvest. VUZ Chern. Met.*, 1960, (2), 112–117) The findings of this investigation show clearly the great value of induction hardening of high-speed steels and the need of different approaches depending on the purpose of the induction hardening as compared with structural and tool steels. For example, a rate of heating in excess of 20°/sec is harmful to these high-speed steels while it improves the properties of the hardened volumes in structural and low alloy tool steels.

Experiments on the inherent stresses in inductively-hardened steel surfaces H. Staudinger (*Härt. Techn. Mitt.*, 1960, **15**, Oct., 160–164) Experimental evidence is given, showing that the magnitude of inherent stresses depends on the ratio of depth of case to the cross-section. For a given cross-section, an increase in case depth results in greater stresses.—R.P.

Various industrial applications of high frequency induction heating H. Nishimura (*Suiyokwai-Shi*, 1958, **13**, Sept., 446–450) High-frequency induction heating is applied not only to the surface hardening of iron and steel, but also the the thorough hardening of steel bars or strips. Furthermore, brazing can easily be carried out by induction heating. Such applications of high-frequency induction heating are briefly described.—R.S.F.C.

The effect of the cooling media on the fine structure of chromium–iron when heated by induction I. N. Kidin (*Izvest. VUZ Chern. Met.*, 1960, (1), 142–146) Tests were carried out to establish the effect of the rate of cooling after induction heating, on the fineness of the structure and on hardness and to establish a relation between the hardness of the chromium–iron and the size of the blocks. The results obtained show the favourable effect of induction heating on the hardness and other properties of steel. The fragmentation of the block mosaics by an increased rate of heating is one of the principal factors for improving the properties of these alloys.

Influence of bath nitriding on wear and fatigue strength B. Finnern (*Schweizer Arch.*, 1960, **26**, Sept., 347–355) The mechanism of salt-bath nitriding and the practical application of the process to structural components which are subjected to wear and alternating stresses is discussed, with examples (19 refs).

Titaniding steel in a bath of fused sodium chloride A. N. Minkevich and A. G. Gvozdev (*Izvest. VUZ Chern. Met.*, 1960, (2), 151–156) Titaniding proceeds satisfactorily between 950 and 1100° with holding time between 0·5 to 2 h in a bath containing 80–90% fused NaCl and 10–20%TiO_2 alloy (containing about 10% (atomic) O_2). Industrially this operation is carried out with the bath under a shielding atmosphere of argon.

The morphology of 'Sulfinuz' treated surfaces R. Desbrandes (*Met. Corr. Ind.*, 1960, Oct., 353–378; Nov., 416–434) The structure of the layers produced on carbon and alloy steels, nitriding steels and grey cast iron treated at 570°C in salt baths containing sodium cyanide and sulphide was studied by metallographic and microhardness tests. The process was compared with nitriding in ammonia and in a sulphur-free nitriding salt bath. The effect of annealing the 'Sulfinuz' coating was also investigated (26 refs).—A.D.H.

A new continuous annealing process J. A. Edwards (*Prod. Fin.*, **13**, Oct., 98–99) 'Flash annealing' by means of the flash induction heater is briefly described.—S.H.-S.

Electrically-heated elevator furnaces for annealing blackheart-malleable castings J. M. Paton (*Found. Trade J.*, 1960, **109**, Nov. 10, 595–598) The nature and installation of these furnaces at three works are described. The economies are indicated and the cleanliness of this method is stressed.—C.V.

The annealing of high carbon cold rolled strip I. Wray and W. Nuske (*BHP Tech. Bull.*, 1960, **4**, Nov., 15–21) Adjustment of furnace zone setting during annealing has given a more uniform product and the slower rate of the furnace charge is more than counterbalanced by the reduction in holding time at the annealing temp. producing a high quality spheroidized annealed strip. Microstructural examination and bend testing indicate complete absence of pearlite. Also it is unnecessary to remove the outside wraps of coils failing to pass bend tests due to overheating during annealing; this has speeded up the finishing end of the mill. Based on overall annealing cycle, a reduction in furnace time of 10–20% has resulted.—C.V.

Stress relieving A. J. P. Tucker (*Engineer Foundryman*, 1960, **25**, Feb., 36–37) The normal stress relief procedure for welded mild steel equipment is heating to a uniform temperature in the range 600–650°C. At such temp. the creep strength of the steel is low and the locked up stresses are able to relieve themselves so that after heat-treatment the residual stresses are only of the order of the creep strength of the steel at the stress relief temp., i.e. about 2 t/in². The heating and cooling should be uniform and done gradually.

Stress relieving in annealing heat resisting weldable steels P. Brozzo (*Rivista Ital., Saldatura*, 1960, **12**, Sept.–Oct., 209–221) The author illustrates a number of torsion relaxation tests carried out on four types of Cr and Cr–Mo heat resisting weldable steels under different heat conditions in order to obtain useful information for stress-relieving such steels. The influence of chemical composition of the steels on the stress relieving behaviour is considered in detail.

Stress relieving by flexible furnace (*Metallurgia*, 1960, **62**, Aug., 65–68) Details are given of the stress relieving of 80-ft fabricated bridge girders for a road bridge. This work was carried out for the Fairfield Shipbuilding Engineering Co. Ltd, by Electrothermal Engineering Ltd, using their 'flexible furnace' system. These consist essentially of flexible ceramic bead mats, which can give a max. mat temp. of 1000°C. Temp. can be adjusted by varying a number of electrical circuits.

Temperature for rapid uniaxial stress relief of heat-resistant alloys H. S. Avery (*Weld. J.* 1960, **39**, Nov., 509s–512s) A hot-test method here described is claimed to get the necessary data for stress relief more quickly than do conventional methods.

The use of the pearlite number in judging annealing results of Ck60 M. Röhle (*Härt. Techn. Mitt.*, 1960, **15**, Oct., 146–149) An improved method of judging annealing results is described, using the degree of formation, grain size of cementite, and the new structural direction. The use of a suffix is advocated which denotes the initial state of the material. The method is quicker and cheaper than using the tensile test for evaluating properties.

Heat-treatment of spheroidal iron (*Fonderia*, 1960, **9**, Oct., 454–455) The article describes reduction of internal tensions, normalization and blazing off, tempering, austempering and martempering, and surface hardening. It is concluded that the heat-treatment of spheroidal iron presents no greater difficulty than of grey irons. The same equipment can be used. Spheroidal iron is dimensionally more stable than grey iron, which is a further advantage.

The present state of quenching techniques K. H. Kopietz (*Härt. Techn. Mitt.*, 1960, **15**, Oct., 149–154) The quenching process is described from a theoretical point of view. This is followed by a discussion of cooling in relation to section size. Various industrial quenching media are described and compared.—R.P.

Control of press quenching Ford Motor Co. (*Process Control Autom.*, 1960, **7**, Oct., 493) A system of control of gear parts treatment by quenching when the required temp. is attained or measured by radiation pyrometers. A three-stage quenching cycle is used.

On step-quenching and delay-quenching in induction surface hardening H. Nishimura and Y. Mitani (*Suiyokwai-Shi*, 1955, **12**, June, 481–484) A method of withdrawing the specimen before the temp. has fallen to that of the quenching medium and one of delaying quenching after heating is stopped are described.

Investigation on increasing the strength of low carbon steel wire T. Nishihara, M. Kakuzen, H. Nakamura, and K. Mizuma (*Proc. Ist Japan Congress on Testing Materials*, 1958, 100–102) It is shown that hardness and tensile strength of low-C steel wires are greatly increased by suitable quenching, but they retain sufficient ductility for satisfactory cold drawing.

The mechanism of the formation of the carbide phase during the tempering of type EI-69 steel L. I. Lysak and A. G. Drachinskaya (*Voprosy. Fiz. Met., Metallov.*, 1960, (11), 22–27) It was established that the grains of the cube and of the dodecahedron of the carbide phase are parallel to the same grains of the austenite lattice tempered at the same temp. (650, 750, 800, and 950°C).—A.I.P.

Magnetometric investigations of the tempering of quenched steels during electric heating V. N. Gridnev and Yu. Ya. Meshkov (*Voprosy. Fiz. Met. Metallov.*, 1960, (11), 74–81) Interesting results were obtained concerning the processes of the disintegration of residual austenite and the removal of internal stresses during the electric heating of steel at a rate of about 300°/sec.—A.I.P.

The electric tempering of chromium steels V. N. Gridnev, Yu. Ya. Meshkov, and V. K. Sul'zhenko (*Voprosy Fiz. Met. Metallov.*, 1960, (11), 87–93) The change in the fine structure and mechanical properties was studied during the electric tempering of grades 38KhA and 8hKh6 steels. During such tempering a special structural state of the steel occurs, which in comparison with normal tempering is characterized by high values of second degree deformations, a higher degree of dispersion of coherent regions (blocks), and a higher degree of dispersion of carbide segregates. After electric tempering structural steels (38KhA) have high

strength values with completely satisfactory ductility.—A.I.P.

Tempering steel in rigid devices A. P. Gulyaev and Z. A. Kraineva (*Izvest. VUZ Chern. Met.*, 1960, (2), 121–123) Components, specially long ones, become distorted during hardening owing to internal stresses. Straightening devices are in use which can correct this distortion during the relatively short time of hardening. Experiments have shown that the degree of correction of the deformation during tempering in a rigid device depends only on the tempering temp. and will be about the same for any degree of deformation during hardening.

Ni-hard grinding balls far outlive steel R. H. T. Dixon (*Engineering*, 1960, **190,** Nov. 4, 598–599) Double tempering of Ni-hard cast iron balls increases their already high abrasive resistance so that their life is 14 times as long as that of steel balls under practical sinter milling conditions. Economies are discussed.

FORGING, DRAWING, STAMPING AND PRESSING

Some analytical and experimental studies of axi-symmetric cold forging and extrusion—I H. Kudo (*Internat. J. Mech. Sci.*, 1960, **2,** Oct., 102–127) Upper-bound solutions are obtained for forging and extrusion from the Mises yield criterion and Levy-Mises stress-strain-rate relations, examining two types of velocity fields. The concept of unit cylindrical deforming region is introduced and rates of energy dissipation are found. Some practical cases are worked out giving values in agreement with experiment.

This automated plant forges railway wheels and axles (*Metalw. Prod.*, 1960, **104,** Sept. 21, 71–72) The wheel forge plant of Taylor Bros. & Co. Ltd, at Trafford Park, with a diagram of its general layout and principal elements, and up-to-date operative control conditions, is briefly described.—S.H.-S.

Designing a drawdown forging press J. G. Frith (*Engineering*, 1960, **190,** Nov. 11, 666–667) The advantages of a drawdown press are summarized, operating gear is below floor level, fire hazards are reduced, and there is better access for forging, handling, and tool changing. This design has been adopted for a new 3000 t unit which is to replace an old press of the same power.—C.V.

Some aspects of press forging S. Kobayashi, A. G. Macdonald, and E. G. Thomsen (*Internat. J. Mech. Sci.*, 1960, **1,** April, 282–300) A comparison of the average and local forging pressures of commercially pure lead cylinders compressed between flat parallel dies as in upsetting is in good agreement with a simplified forging theory. Similar comparisons of average forging pressures with theoretical values based on a disc theory for forging cylinders in closed dies also show substantial agreement. Variation from this was thought to be due to bulging of the flash, failure to retain lubrication and possible failure to correct stresses due to flash overhang. Local pressure distributions in the flash appear to be as predicted by theory but adjustment by plastic flow of the metal within the body of the forging apparently permits readjustment of the local pressure; this results in a more uniform pressure distribution.

5000-ton hobbing press (*Metallurgia*, 1960, **62,** Aug., 60) A description of the press constructed by the Hydraulic Engineering Co. Ltd., of Chester for a large drop forging organization.

An upper-bound approach to plane-strain forging and extrusion H. Kudo (*Internat. J. Mech. Sci.*, 1960, **1,** April, 229–252) This approach was previously developed (Kudo, *ibid.*, 1959, **1,** 57) and applied, and the results gave the requisite degree of accuracy. The steady-state extrusion and piercing pressures agreed with those derived from the slip-line theory within an error of 10% for a range of reductions 0·2 to 0·95 and the most suitable velocity fields giving the min. upper bounds resembled essentially the corresponding slip-line fields. Extrusion presses for a three-orifice extrusion and a sideways extrusion are about equal to those for the usual extrusion having the same total reduction. With a stepped extrusion, the working pressure is a little higher than in the usual extrusion process with an identical reduction. With extrusion forging and piercing forging, working pressures vary with thickness of the slug and depend on the lubrication. However, these pressures and the most suitable velocity fields show good agreement with slip-line solutions. An explanation for the formation of extrusion defects is given. Some opposed extrusion-forgings with both top and bottom dies having orifices are analysed and their working pressures are found to be lower than those found for the one-way method. A method of estimating coining pressure with perfectly closed dies is proposed using the velocity fields for extrusion and piercing.—C.V.

Systematic study of thin pressed steel parts C. Caillot (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.12) [In French] An improved method for studying deformations in thin pressed steel or strip is described. The usual quadratic design on the blanks is supplemented by circles tangential to these squares; the directions of principal strains can be determined after deformation and the extent of deformation is given by using the radius of the circle within the square as the basic initial strength. It is recommended that the network be traced by using the silk screen principle.—B.P.

New design for a two-stage pump V. A. Lyubchenko and M. Z. Loshak (*Vestnik Mash.*, 1958, **6,** 33; from *LLU Translations Bull.*, 1960, **2,** Nov., 974–975) This two-stage pump is intended for pumping mineral oil. The gear pump develops a pressure up to 20 kg/cm² (100 l/min) while the plunger axial pump can give 320 kg/cm² (8 l/min) the output of the pumps being shown in brackets. It is operated at 1460 rpm. The volumetric coefficient of the plunger pump is 0·785 and of the gear pump 0·82. The simplicity and compactness suggest its application to hydraulic systems of machine tools, hydraulic presses, etc.—C.V.

Teflon-and-steel die forms high-strength alloys (*Metalw. Prod.*, 1960, **104,** Oct. 12, 82) A method is described whereby thin high-strength Ti and stainless steel alloys are formed with a universal steel box and a shaped Teflon die at Chance Vought Aircraft's Aeronautics Division. A saving of 30% on conventional forming methods is claimed.—S.H.-S.

Forming wide plate by detonating a gaseous mixture (*Usine Nouv.*, 1960, **16,** Dec. 22, 35) The detonation of a gaseous mixture has certain advantages over solid or liquid explosives, as the impact is less violent and less prolonged. Eight parts of oxygen to one part of hydrogen by weight are considered sufficient. McCallum of the Battelle Institute has invented an electrolytic generator which can weld at high temp., or form large pieces by explosion.

Principles and practice of explosive metal forming L. Zernow (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.3) [In English] The theory and practice of explosive metal forming are discussed briefly.

Forming techniques for stainless steel J. M. Henderson (*Can. Metals*, 1960, **23,** Aug., 58–60) The special problems are discussed. Stretch, flexible-die, high-pressure hydraulic and rubber pad, and roll forming techniques are outlined, their applicability and advantages being indicated. The protection of stainless steel sheets is stressed so as to minimize scratching and marring.—C.V.

An appraisal of the theory of deep drawing J. M. Alexander (*Met. Rev.*, 1960, **5,** (19), 349–419) A comprehensive mathematical review, in which experimental and theoretical investigations are examined and compared, with a brief summary of discussions on theoretical investigations of the deep drawing process.—S.H.-S.

Plane strain theories of drawing A. P. Green (*Inst. Mech. Eng.*, 1960, preprint, pp.16) Existing theories of drawing under conditions of plane strain are reviewed and slightly extended. One of the approximate theories, in which work hardening is neglected, is reasonably accurate in predicting the distribution of pressure on the die and the effect of friction on the drawing load. A further approximation is proposed which makes allowance for friction, work hardening, and redundant work; this latter is taken into consideration by modifying the stress-strain curve of the metal. Formulae are derived for drawing through a wedge-shaped die but similar formulae have not been found for cylindrical profiled dies. Possible errors involved in calculating a mean coefficient of friction from the measurement of forces acting on each half of the wedge-shaped die are analysed.—C.V.

Factors affecting the drawability of sheet steel R. L. Whiteley (*AISI Preprint*, 1960, pp.17) The principles of the deep drawing process are discussed and an attempt made to illustrate them schematically. The success of a deep drawing operation is shown to depend on three factors: the depth of draw, the character of the drawing operation, and the drawability of the sheet material. These factors are discussed in relation to tool design and material properties. Drawability is stated to depend on the ductility and the anisotropy of the material being drawn. The importance of anisotropy is emphasized and its relation to drawability defined.—R.S.F.C.

Drawing techniques for stainless steel J. M. Henderson (*Can. Metalw.*, 1960, **23,** July, 40–43) A general discussion on dies, drawing lubricants, annealing, and pickling. Analyses and typical mechanical properties of 11 stainless steels, and the annealing temp. of 15 Cr-Ni and 4 Cr steels are presented in tabular form.—C.V.

Bending plus stretching cuts cost of contoured sheet parts D. Peckner (*Mat. Des. Eng.*, 1960, **52,** Oct., 115–116) Stainless steels are included. The advantages of the process are set out as worked by the Anderson Aircraft Corp. and called the Androform Process.

An investigation of the plug drawing process T. Z. Blazynski and I. M. Cole (*IME Advance Copy*, 1960, Sept. 30, pp.10) Tube drawing from a 0·12%C steel was treated by the existing theory and general agreement is shown to exist if true mean yield stress and coefficient of friction are known. The method of obtaining these is considered.

Flow-forming. II E. J. Bennett (*Aircraft Prodn.*, 1960, **22,** Nov., 438–444) Further descriptions of the Lodge and Shipley Floturning process are given, here with special reference to the no.12 vertical machine. Combinations with press re-forming and other developments are included.

The influence of thickness variation of sheet on deep drawing results G. Oehler (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.8) [In German] The author discusses tolerances for the thickness of sheet metal in relation to the shape to be drawn.

Experiments regarding the drawing of complex hollow parts A. D. Tomlenow (*International Deep Drawing Research Group. Société Française de Métallurgique. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.8) [In German] Stress conditions and drawing stability of complex hollow parts are discussed. The application of Henky's theorem to such parts is shown to be justified. It is thought that maximum uniform deformations are greater than those expected from tensile tests.—B.P.

Evaluation of drawing properties of sheet steel L. A. Rubenkova (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.7) [In English] The drawing properties of sheet steel are discussed, using data obtained from uniaxial and biaxial tensile tests. Plasticity and stress-hardening are shown to be the most important factors affecting drawing. It is recommended that drawing properties be estimated from biaxial tension since instability occurs later than in uniaxial tension.—R.P.

The problem of assessing the method for determining the deep drawing capacity of steel sheet B. M. Ovsyannikov (*International Deep Drawing Research Group. Société Française de*

Métallurgie. Colloque sur la Mise en Forme des Tôles Minçes et les Essais de Tôles, 1960, May, pp.23) [In English] Experimental results are discussed which show that the 'pattern' methods of testing can be used for assessing the deep drawing properties of various low carbon steels when a hollow, parabolic shape is to be drawn. It is noted that results obtained experimentally agree well with industrial tests.

Double-action hydroforming process S. Fukui, K. Yoshida, and K. Abe (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.9) [In English] The hydroforming and double-action hydroforming methods are compared from theoretical and practical points of view. Advantages and limitations of these methods are pointed out.

Formability of sheet metal in successive multistep drawing I. Noritzin (*International Deep Drawing Research Group. Société Française de Métallurgique. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.20) [In English] Experimental and theoretical results are discussed regarding multi-stage drawing without intermediate annealing, using successive dies and multistage presses. Conditions for high formability are suggested. Drawing of flanged and flangeless cups is dealt with.—B.P.

A stretch-forming test for use with a variable speed drawing press D. V. Wilson, B. B. Moreton, and R. D. Butler (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.18) [In English] A modified Swift drawing press is described using a standard 2-in punch and allowing a choice of penetration speeds up to about 100 ft/min. Advantages of this tool are shown by experimental results. A rapid test is described which eliminates the necessity of stopping the punch at the exact moment of fracture.—B.P.

Investigation regarding the formability of thin sheet metal, starting from laboratory tests. Development of a draw part, typical of car body parts M. Jentet (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.19) [In French] It is emphasized that previous work on improved tooling to facilitate metal flow during deep drawing is insufficient for car body parts. Comparison of conventional characteristics with critical diameters given by this type of drawn part resulted in the establishment of laws of correlation. Results are compared with those obtained with cylindrical shells, thus relating new results with former investigations.

Research in drawability tests J. Pomey, A. Royez, and P. Dhez (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.29) [In French] Stress and strain distributions are discussed in relation to deformation and drawability. Friction and lubrication are dealt with and attempts are made at defining drawability, taking the cupping test into account. The work continues.—B.P.

Cold forming of thin sheet and deep drawing tests J. Guyot (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.12) [In French] It is pointed out that the nature of the deformation produced in deep drawing has to be taken into account when testing. A research and a routine method of testing deformation are described and results obtained are compared. It is suggested that drawability consists of the components: expansion, contraction, and linear expansion; the predominant component will determine the method of testing to be chosen.—B.P.

The application of phase change lubrication to stretchforming J. F. Wallace (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.12) [In English] The theory of ice films on strip is discussed and suggestions put forward as to their mode of functioning, during stretch-forming. The experimental determination of friction during stretch-forming is dealt with briefly and results obtained are discussed, including the use of ice, lanolin, and graphite lubricants.—B.P.

Drawability and anisotropy of metals R. L. Whiteley, D. E. Wise, and D. J. Blickwede (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise in Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.12) [In English] It is shown that anisotropy can be at least as important as ductility in obtaining good drawability. In most cases, drawability measurements have to depend on strain hardening properties as well as on anisotropy. Both properties can be measured by the tensile test.

How to improve shear-forming techniques S. Kalpakcioglu and R. L. Kegg (*Metalw. Prod.* 1960, **104,** Oct. 12, 91–92) Three components of force exerted by each roller on a Cincinnati Hydrospin are measured by strain-gauge dynamometers. Stress-strain diagrams for various metals, showing relative resistance to shear-forming and, secondly, how shear-formability is indicated by test of tensile-reduction-in-area of work-material samples, are presented.—S.H.-S.

Quality control in the wire industry E. F. Jubb (*Wire World Int.*, 1960, **2,** Oct., 229–233) Analytical control, from rod sampling, through the wire drawing, annealing, and galvanizing stages, with simple mathematical techniques used in statistical quality control, are briefly reviewed.—S.H.-S.

American and European wire manufacturing. A comparison R. S. Worth (*Wire Wire Prod.*, 1960, **35,** Dec., 1672–1673) A review in very general terms.—C.V.

Cold heading E. F. Tauscher (*Mach. Design*, 1960, **32,** Aug. 18, 185–186) The determination of the amount of stock required for the head in relation to the wire dia. indicates whether a part can be produced by cold heading. A 'headability index' is suggested; this is the ratio of the length of wire required for the head to the dia. and a rapid method for finding this ratio and for calculating the weight of the parts is provided.—C.V.

Design for cold heading T. B. Smith (*Wire Wire Prod.*, 1960, **35,** Sept., 1113–1120, 1184–1185) A detailed treatise on cold heading, stressing the problems encountered in cold forming of fasteners in different types of metals with an exhaustive series of examples of processes, materials, and products.—S.H.-S.

Cold heading and cold extrusion of wire J. C McMurray (*Wire Wire Prod.*, 1960, **35,** Dec., 1649–1652, 1718–1719) The three primary deformation processes are discussed, upsetting and forward and backward extrusion. Tool load measurement is also dealt with as well as a brief summary on tools, lubricants, and phosphate coatings. The steps in formation of a flat head socket screw, a 1-in heavy hex. head bolt, a ¾-in pipe plug and a valve spring retainer are illustrated with an indication of each process step.—C.V.

Wire speed calculations for extrusion machines W. J. Owens (*Wire Wire Prod.*, 1960, **35,** Sept., 1122–1125) Four nomograms are shown which may be used to plot values for conditions existing in each machine and for every applicable compound and screw speed, and which may serve as 'blanks' for the plotting of specific information for individual machines or groups of machines.—S.H.-S.

The extrusion of metals—Part VIII. Steel under cold impact conditions J. McKenzie and A. R. Rodger (*DSIR, NEL Plasticity Report No.*163, 1959, Sept., pp.46 and figs.) An extensive report on trials on various steels in which many factors were taken into account. Various relationships were found, one between max. pressure and log extrusion rate.

Cold extrusion of steel parts from wire A. Braun (*Wire Wire Prod.*, 1960, **35,** Nov., 1538–1539) A brief account of practice at the Braun Engineering Co.—C.V.

See who's using extruded steel sections *Engineering*, 1960, **190,** Nov. 25, 706–707) Examples of special-use steel extrusions are illustrated and discussed; the essential properties and characteristics being included.—C.V.

Cold extrusion: A market for rod and wire R. W. Perry (*Wire Wire Prod.*, 1960, **35,** Oct., 1355–1358) Closer tolerances, improved surface finish and lower labour costs are claimed. Lubrication and phosphate coating are discussed.—C.V.

The application of steel extrusions R. D. C. Jones (*Weld. Met. Fab.*, 1960, **28,** Dec., 495–498) The combination of extrusions and cold drawing is discussed. This preshaping method shows considerable saving in cost, reduces waste material, and results in more accurate cold drawing. Numerous examples are provided.—C.V.

ROLLING MILL PRACTICE

The theory of working of metals from the point of view of metal physics H. P. Stüwe (*Stahl Eisen*, 1960, **80,** Dec. 22, 1963–1969) Based on two models for continuous rolling the particular significance of material coefficients is stressed for the theory of working of metals, for instance the coefficient of friction and that of resistance against deformation. Other effects are also considered in this discussion (26 refs).—T.G.

The present state of rolling force calculation due to A. I. Zelikov P. Funke jun. (*Stahl Eisen*, 1960, **80,** Dec. 22, 1971–1972) The known formulae for the calculation of rolling force can be divided into two groups: The first is that due to Cetto and to Ekelund which is based on conclusions drawn from experiments. The second is based more on theoretical assumptions and includes names such as Bland and Ford and more recently Zelikov. The present author reviews and discusses work published by Zelikov (8 refs).—T.G.

The phenomena of bending and flattening of the rolls in 4-high mills B. Fazan (*Rev. Mét.*, 1960, **57,** Nov., 1003–1018) An experimental study was made of a rolling mill with 300 mm parallel-ground rolls, to determine the stress distribution between the work- and back-up rolls. It is shown that the results obtained experimentally are much higher than those calculated by the Caswell-Winkler formulas for the bending of the rolls of a 4-high mill. With short, massive rolls flattening produced deformations of the same order as those from bending and shearing.

An investigation of the pilger process by a plane strain analogue D. H. Sansome and H. K. Lloyd (*J. Mech. Eng. Sci.*, 1960, **2,** Dec., 359–371) Reference to publications relating to this process suggests that agreement is lacking as to the most desirable type of roll profile to use; furthermore the knowledge of loads and torques involved is far from complete. An apparatus capable of simulating this process under plane strain conditions was adapted to a milling machine; Pb was the working material and load, torque and speed were measured. The two-dimensional analogue was chosen to eliminate some of the many variables normally met with. It has been shown that factors such as roll profile, amount of reduction and feed per blow will affect loads and torques; it is also evident that under certain conditions a parabolic cone is more desirable than the hyperbolic. However, to produce the most acceptable tube, it is possible that the theory and practice need not entirely agree. A theory has been evolved to enable loads and torques to be predicted for the plane strain analogue based on Hill's indentation theory.—C.V.

Comparison between calculated rolling load and measurements T. Okamoto (*Sumi Met.*, 1960, **12,** Jan., 323–330) Published measurements agree with calculations from the formula of Orowan and Sims (when suitable values for resistance to deformation are used), but not with those from Ekelund's formula.—K.E.J.

The use of upper-bound solutions for the determination of temperature distributions in fast hot rolling and axi-symmetric extrusion processes W. Johnson and H. Kudo (*Internat. J. Mech. Sci.*, 1960, **1,** April, 175–191) In a fast working process the heat loss by radiation and conduction can be neglected if at the outset the processed material and the surroundings were at about the same temp. Temp. equalization throughout the body in the deforming region is also negligible if only a short time is

involved and on these assumptions the local temp. rise in a small volume of material is ∝ to the plastic work expended on the material. From this the temp. rise at each point in the deforming region is calculable if the local rate of work can be calculated. In the present work certain assumptions have been made and no account is taken of roll distortion, radiation losses, conduction losses due to dies and rolls, variation of yield stress, and temp. and the working of a non-homogeneous medium. The two cases of axi-symmetric processes here examined involve 0·75 reduction; firstly for extrusion through a square die, two forms of velocity field are presented and the results predicted therefrom are compared; secondly extrusion through a smooth conical die is examined.—C.V.

Roll design for the economical and normal double-T section M. Musial (*Hutnik*, 1960, **27**, (9), 328–332) The author points out that double-T (H) sections with thin webs and wide feet are considerably more efficient for the building industry than the PE section (normalized European). He goes on to describe the technique of manufacture of these sections and with profuse illustrations gives two proposed methods for the calibrating of these new double-T sections.

Trials with very large rolls in Eastern Germany Z. Wusatowski (*Hutnik*, 1960, **27**, (9), 334–338) The author described the results of laboratory and production experiments and then goes on to a discussion of results. It was found that steel with a carbon content up to 0·73% can be rolled satisfactorily. The discussion was somewhat limited by the fact that results could be obtained only in the later stages of rolling.

The viscosity-pressure relationship of mineral oils U. Rost (*Stahl Eisen*, 1960, **80**, Dec. 22, 1973–1974) Recently attention has been drawn to the importance of the pressure dependence of the viscosity of mineral oils in addition to the temp. dependence. Under the severe conditions prevailing in rolling mill bearings the pressure effect should not be neglected. The author reviews recent publications on the subject and stresses the importance of additions to the oil on the pressure-viscosity behaviour.—T.G.

Automation by means of punched cards of a 1120 mm blooming mill, including the soaking pit installation H. Krüger (*Neue Hütte*, 1960, **5**, Dec., 720–729) The automation of a heavy blooming and slabbing mill is described, in which the programming of the mill and the material flow are covered by a common punched card system. The control and signalling arrangements are described (17 refs).

Rapid change-over of continuous light- and medium-section mills L. Wegmann (*Demag. News*, 1960, (158), 1–4) Stand changing procedure is briefly described.

Hot rolled sections for light metal construction (*Usine Nouv.*, 1960, **16**, Dec. 1, 107) This is an account of a visit to the Isberques Works of Compagnie des Forges de Chatillon Commentry et Neuves Maison which produces high quality and tolerance metal sections. A detailed description of the finishing processes are given including treatment for corrosion resistance. The works consist of coke ovens, three blast-furnaces, three OH furnaces, and a bar mill producing 250 various sections a day. From April 1961, the works will produce exclusively shotblasted and galvanized sections covering the entire range of special sections for light metal construction.

Steel bar for pre-stressed concrete T. Fujii, N. Yamagoshi, and T. Igarashi (*Procs. of the Symp. on Prestressed Concrete and Composite Beams, Science Council of Japan*, 1955, Nov., 1–5) [In English] Trial production of a steel bar by rolling or by cold drawing is described.

Reprofiling of used rails at the Saint Dizier Workshops Wautier and Vennin (**Revue Générale des Chemins de Fer*, 1960, July–Aug., 402–403).

Wire rod mill layout (*Wire Ind.*, 1958, **25**, May, 469–470) An installation by F. Krupp-Grusenwerk, Magdeburg, is described for rolling angle irons, T-sections, and wire rods; the whole plant is housed in a hall 380 × 73 ft equipped with an 8-t travelling crane. The billets leave the furnace, are transported to the roughing mill, and while the first pass is made by hand repeaters are used for subsequent passes. The oval bar enters the mill automatically and at the rear of the stands it is introduced into the different grooves; bars discharged from the last stand pass directly to the finishing mill or go to the cooling bed via a rotary shear. The location, distance of travel, etc., of the various units are described.—C.V.

Wire rod defects—their occurrence and detection G. Earnshaw (*Wire World Int.*, 1960, **2**, Oct., 233–238) A brief survey of steel rod control, covering steelmaking defects, surface faults, structural defects, sampling, sulphur printing, deep-etch test, with interpretation of results, and types of failure in wire drawing is presented.—S.H.-S.

Views on a possible Spanish classification for thin sheet P. Gómez Baeza (*Tech. Met.*, 1960, **16**, Sept.–Oct., 175–188) [In Spanish] The most important characteristics of the tables of standard types and designations most used by Spanish industry are discussed with the aim of evaluating their advantages and inconveniences. Use is made of these conclusions to suggest a provisional, official table and the tests needed to guarantee quality. Some selection criteria which should help in the choice of typical classes of steels from the point of view of their conformability are indicated.—P.S.

Heavy plate mill commissioned at Rourkela steel plant (*Iron Steel Rev.*, 1960, **4**, Sept., 31–32) A brief description of this mill, built by Krupps, is given with estimates of output etc.

Progress at Consett (*Engineering*, 1960, **190**, 351) A very brief illustrated report on the 4-high plate mill.—C.V.

Consett's new plate mill (*Anvil*, 1960, **5**, Autumn, 12–19) The layout, equipment, operation, processes, and products of the new Howngill plant are described and illustrated, with special features and projected future plans for the works are indicated.—S.H.-S.

Some unusual defects on flat products J. Le Bas (*BHP Tech. Bull.*, 1960, **4**, Nov., 26–32) Deep scratches on coiled strip, numerous small black specks on tinplate sheet, and indentations of various sizes on tinplate are discussed in relation to cause; photomicrographs are presented.—C.V.

On the scope of punched card methods in the planning of production in sheet mills on the basis of customers' orders V. Šmíd (*Hutn. Listy*, 1960, **15**, (9), 710–719) It is shown, by means of examples, how punched card methods can contribute to the rationalization of production schedules in the manufacture of strip and sheet.—P.F.

Rapid calculations for a continuous rolling mill Z. Orzechowski (*Hutnik*, 1960, **27**, (6), 224–229) The method enables quick and accurate calculations of extensions between stages to be made. The article gives the method in detail giving in addition tables of constants used in the calculations and some worked examples.

Hot rolled carbon steel strip AISI (*AISI Steel Prod. Manual*, 1960, Oct., pp.28) The issue of October 1957 is revised.—C.V.

Tin mill products (*AISI Steel Prod. Man.*, 1960, Nov., pp.38) History, manufacturing processes, black plate, tin plate, short terne plate, and hollow-ware, enamelling stock, and blued plate are briefly reviewed.—C.V.

The influence of strip weight fluctuations on the yield in thin sheet production J. Pavel (*Hutn. Listy*, 1960, **15**, (9), 689–694) A statistical analysis is made of the losses incurred due to weight inequalities in the simultaneous rolling of two or more strips. Losses can be minimized by rolling jointly pieces of strip which have been neighbours in the process of being produced.—P.F.

Automation in continuous rolling mill trains R. Zwicky (**ETZ–A*, 1957, **78**, Dec., 869–873) In step with the general advance of automation and rationalization in manufacturing industry, automatic control, and regulation of the entire rolling mill, consistent with the importance of its semi-products, has continued to attract interest in the past decade. The problems associated with the automation of continuous mill trains and guiding principles in the right choice of equipment and accessories available for the purpose, merit detailed explanation. Recent control methods and ancillary equipment are described.—R.S.F.C.

A graphical representation of cold rolling mill yield W. Görecki (*Hutnik*, 1960, **27**, (7–8), 286–295) The author first gives the effect of roller weight, rolling speed, and other factors on output and then shows the results in graphical form. In conclusion he describes the use to which these graphs can be put.

The determination of the friction coefficient in cold rolling P. Funke jun. (*Stahl Eisen*, 1960, **80**, Dec. 22, 1969–1971) The determination of the friction coefficient in the roll gap and the resistance of the material against deformation is one of the most important factors in cold rolling calculation. Recently a number of experimental determinations of the friction coefficient have been made by various workers and the present author reviews and discusses their results (7 refs).—T.G.

Structural phenomena in the cold rolling of rimming steel sheet U. Berruti, S. Michelucci, and G. Odone (*Rev. Mét.*, 1960, **57**, Nov., 1019–1031) Work carried out on rolling with an end temp. of 835–880°C is reported. It was shown that, given a holding period, after deformation, at a sufficiently high temp., recrystallization is produced varying with the amount of deformation. Absence of coarse grain structure indicates that the coiling temp. was low.

An analysis of cold strip rolling D. Jortner, J. F. Osterle, and C. F. Zorowski (*Internat. J. Mech. Sci.*, 1960, **2**, Nov., 179–194) A very detailed analysis is presented which is designed to predict the min. strip thickness obtainable without exceeding a specified rolling load. This limiting condition occurs when the entire region of contact becomes elastic with the stresses satisfying the yield criterion at only one location. A further application is the prediction of the amount of lateral-edge taper on the strip. The results of a number of examples are presented and compared with experimental findings.—C.V.

Maximum reduction in cold strip rolling B. Avitzur (*IME Advance Copy*, 1960, Dec. 30, pp.13) An equation with a graphical solution is derived and power consumptions in various locations of the rolling trains are computed.

Cold rolled carbon spring steel (*AISI Steel Prod. Manual*, 1960, Nov., pp.34) The max. C-content of this is over 0·25% by ladle analysis. Some metallurgical aspects are considered and manufacturing methods and practices are reviewed; a summarized description of the different qualities is given and the chemical composition and methods of sampling are indicated.—C.V.

Cold rolled dynamo strips H. Schlüter and F. Stäblein (**ETZ–A*, 1959, **80**, Sept. 1, 576–582) In many industrial spheres the proportion of material processed into cold rolled strips is increasing, whereas the hot rolled sheet production is decreasing. In order to inform the clients using electro-sheets about the problems involved, the authors deal with the differences between hot rolled sheet and cold strip production; also they deal with the mechanical and electrical characteristics in so far as they are of general importance.—R.S.F.C.

[Output at Woodstock plant of Standard Tube:] 100 tons of tubing rolled daily G. A. Bell (*Can. Metalw.*, 1960, **23**, July, 34–36) The company at present produces electric welded steel tubing up to 3in dia.; a new installation will enable this to be increased to 5½in. The mill is designed to produce shaped as well as round tubing and an output of 25 000–50 000 t/year is envisaged depending on dia. and wall-thickness. A general description of the capacity is given and illustrated.—C.V.

Electric drive control of Bhilai rolling mills (*Iron Steel Rev.*, 1960, **4**, Sept., 33–34) A brief account without technical details.—C.V.

Drive for blooming mills of Lenin works type L. Kule (*Czech. Heavy Ind.*, 1960, (11), 42–47) The main prerequisite is rapid starting, stopping, and reversing. The various considerations are discussed. Regulation of the motor field, de-energizing, and energizing of the motor and the necessary circuits are examined. In the system under review, only rotary amplifiers are used.—C.V.

Isotope contactless thickness meter for hot rolled steel plates T. Florkowski and L. Górski (*Hutnik*, 1960, **27,** (7–8), 273–278) The instrument measures in the range 2–12 mm by measuring the gamma absorption from a ^{137}Cs source. The instrument is accurate to ±0·04 mm and gives the result in visual form.

Hydraulic cut-off and upset testing machine increases efficiency in quality control H. M. Webster and H. K. Porter (*Wire Wire Prod.*, 1960, **35,** Sept., 1139, 1183) Two machines used in a large Eastern steel mill for testing steel rod as it comes off the rolling mills are described and the economies resulting from their operation are evaluated.—S.H.-S.

Reasons for disturbances in the operation of flying-shears used in small rolling-mill departments K. Golebiowski (*Hutnik*, 1960, **27,** (9), 332–334) The author first describes the actions of these shears and their mode of normal operation and then goes on to deal with abnormal disturbances. These can be caused by: non-instantaneous clutch engagement, incorrect adjustment of a breaking clutch, or by the physical state of the material to be sheared which requires more power than is available in the shears.

MACHINERY AND SERVICES FOR IRON AND STEELWORKS

Crane safety in the iron and steel industry (*BISF*, 1–54, Appendices I–XVI) A survey of accidents, safety precautions, maintenance, and of types of cranes and lifting tackle.

Considerations on transport planning in metallurgical works H. Sonneck (*Neue Hütte.*, 1960, **5,** Dec., 738–743) Topics dealt with are: general considerations in the planning of transport in a new works; internal transport and its connexion with the external transport network; and conveyor and crane equipment.

Electric points and signal boxes in iron and steel works M. Rieusset (*Génie Civil.*, 1960, **137,** Nov., 446–453) The writer describes the advantages of electric points and signal boxes. Compares mechanical and electric boxes and gives a detailed account of the electric signal boxes at the Hagondange works.

Industrial application of strain gauges for weighing J. Rabalski (*Hutnik*, 1960, **27,** (9), 338–345) The author outlines the theory of electric strain gauges and their application in weighing circuits. This is illustrated by many examples of machines on the market.

WELDING AND FLAME CUTTING

Welding of cast irons D. G. Jones (*Engineer Foundryman*, 1960, **25,** Feb., 37–38) Methods of welding cast irons and equipment used are described.

Repair-welding of cast iron G. M. Blanc (*Schweisstechn.*, 1960, **14,** (12), 133–139) It is shown that technical and economic problems associated with the welding of cast iron can be dealt with. Large sections, it is stated, can be welded efficiently by an electric method. Small parts are pre-heated and then welded autogeneously.—R.P.

Welding has a great future: Some new developments in the USSR B. Paton (*Sci. Eng.*, 1960, **13,** July–Aug., 98–100) A brief review of developments in general terms.

Recent work on pressure welding R. F. Tylecote (*Weld. Met. Fab.*, 1960, **28,** Dec., 491–494) A review (42 refs).—C.V.

Gas metal-arc welding of low-carbon steels G. Christopher and R. C. Becker (*Weld. J.*, 1960, **39,** May, 478–487) The advantages of this method of welding have been investigated and it is concluded that the method is not fully exploited.

Emergency fabrications J. P. Pearson (*Engineer Foundryman*, 1960, **26,** July, 46–50) The writer describes how emergency repairs were carried out to refabricate the main supporting cast-iron cradle of a 300 t press which broke into 11 pieces during the manufacture of tube plates for boilers.

The science of arc welding. II C. E. Jackson (*Weld. J.*, 1960, **39,** May, 177s–190s) This is the second half of the 1959 Adams Lecture. The volt-ampere relationship, distribution of field intensities and temp., metal transfer, spatter, arc forces and motion, melting rate, weld area, and melting ratio are discussed.

All-position welding of HY-80 steel with the gas-shielded process C. R. Sibley (*Weld. J.*, 1960, **39,** Oct., 433s–437s) At present approval of welds of this steel by the dip-transfer technique is limited to flat position work. It is hoped to extend approval to all-position welding in the near future, and the development of all-position welding techniques is described.

Complex steel weldments J. A. Rau and W. F. Fischer (*Weld. J.*, 1960, **39,** Aug., 808–812) The methods of welding used, and precautions taken, in the construction of two 175-t mobile radio-telescopes are described.

Semi-automatic welding in a CO_2 atmosphere B. Pierozek (*Przeglad Spawalnictwa*, 1959, (5), 131—135; from *Polish Tech. Abstr.*, 1960, (37), 49) A method of reducing the amount of spattering is to increase the welding current to such an extent as to preserve the proper relation of carbon to silicon in the weld material and to shorten the electric arc to its most suitable length, $\frac{1}{8}$in, and to weld by means of the positive pole. Features are low cost, higher welding speed, deeper fusion depth than with argon, and greater arc elasticity.

New automatic equipment for welding with shielded arc S. Sokolowski (*Przeglad Spawalnictwa*, 1959, (8), 210–212; from *Polish Tech. Abstr.*, 1960, (37), 51) Universal apparatus is described for welding with shielded arc, the stroke of the electrode being dependent on the voltage of the arc and the current adjusted within the range of 300 to 1 200 A. A successful test of this automatic welder was carried out in the Konstal works at Chorzow and in the Gdansk Shipyard.

Welding on high-pressure gas-transmission pipe lines R. R. Wright and R. S. Ryan (*Weld. J.*, 1960, **39,** May, 473–477) A method of producing sound, full-penetration welds in branch connexions and hot tops has been developed.

Welding of high-strength low-alloy structural steel for bridges J. L. Beaton and P. G. Jonas (*Weld. J.*, 1960, **39,** Nov., 1117–1123) The success of such welding depends upon close adherence to proper welding procedures, as described here.

Welding of galvanized steel-cracking mechanisms and development of solutions J. F. Rudy (*Weld. J.*, 1960, **39,** May, 212s–218s) A literature review of this subject was carried out, and an experimental program is described aimed at eliminating this type of cracking. Two techniques for doing this are given.

Effect of steel backup blocks on series spot welding E. F. Nippes, W. F. Savage, and K. C. Wu (*Weld. J.*, 1960, **39,** Aug., 321s–326s) The results of an investigation into backup blocks of steel rather than of the usual copper or copper alloy are given.

Welding of high-strength steels for rocket cases W. H. Kearns, J. W. Semmel, and J. D. Marble (*Weld. J.*, 1960, **39,** Nov., 484s–492s) The whole problem of welding high-strength low-alloy steels has been considered, and a study made of the weldability of three typical steels. Techniques were developed for improving their weldability, and recommendations are made as a result.

Welding of nickel-chromium-iron alloy for nuclear power stations C. E. Witherell (*Weld. J.*, 1960, **39,** Nov., 473s–478s) A 15%Cr, 7%Fe Ni alloy is used extensively in this field. A new covered electrode has been developed, that allows crack-free and porosity-free welds to be made in all positions even under severely restrained conditions. The process is particularly suited to the welding of this alloy to iron and stainless steel, and welds produced by these new materials have good mechanical properties that are not adversely affected by normal stress-relieving heat-treatments.

Properties of chromium-steel weld metal J. Heuschkel (*Weld. J.*, 1960, **39,** Nov., 502s–508s) The effect of temp. upon the tensile strength, hardness, and microstructural characteristics of Cr steel welds in described and data are given applicable to design and service needs.

Welding repairs of cavitation on large hydro-electric turbines M. Friedmann jun. (*Weld. J.*, 1960, Nov., 1124–1126) The problems involved in this type of work are given, and methods of overcoming them are described.

Calculations for temperature response in spot welds G. R. Archer (*Weld. J.*, 1960, **39,** Aug., 327s–330s) This type of calculation shows how the frequency, level, and phase control of the power source affects temp. response for single-phase welding. The thickness and thermal characteristics of the material are also considered.

Wear resistant surface layer welding using a horizontal plate electrode B. M. Kontorov and N. V. Popova (*Svar. Proizv.*, 1959, (9), 27–30) From a German version.

The welding of highly alloyed steel with special reference to shielded arc welding H. Müller (*Metalen*, 1960, **15,** Dec. 15, 402–406) [In German] This second instalment of the paper concerns experiments conducted to overcome intercrystalline corrosion and the instability of electrodes at higher welding temp. A wide variety of electrodes of differing compositions was tested and the tensile properties of the resulting welds are tabled. There is also a detailed description of a new method of welding tubes for avoiding any defects inside that may be due to oxidation. In some cases it is stated that instead of the expensive argon, it is possible to use a mixture of 80%N_2 and 20%H_2 with good results.

Quenched and tempered steels for welded structures and vessels J. Lessells (*Alloy Met. Rev.*, 1960, **9,** Sept., 2–8) The composition, mechanical properties, weldability, and applications of Q.T.30 and Q.T.42 are examined and discussed. Q.T.42, modified by suitable tempering to develop notch ductility is called Q.T.342 and this possesses ease of fabrication and good wear resistance. Due to low alloy content this is readily welded in sections up to $\frac{3}{4}$in without preheat if low-potential hydrogen electrodes are used. With thicker plates, a preheat of 100° may be necessary.—C.V.

Stainless steels which do not crack at high temperature and weld perfectly F. C. Hull (*Usine Nouv.*, 1960, **16,** Dec. 1, 109) As a result of experiments carried out on an austenitic steel by varying the Cr and Ni contents and adding various other elements, the Westinghouse laboratory at Pittsburgh, USA, has produced several new qualities of stainless steel which are good for welding and have high heat and mechanical resistance.

The fabrication of tubes for pipe-lines. I. Introduction F. Mallet (*Soud. Techn. Connexes*, 1960, **14,** Sept.–Oct., 369) Reasons are given for setting up a production line for the manufacture of welded tubes. Conditions governing the operation are outlined.—R.P.

The fabrication of tubes for pipe-lines. II. The fabrication of plate for large-diameter welded tubes M. Filliâtre (*Soud. Techn. Connexes*, 1960, **14,** Sept.–Oct., 370–374) Plate rolling machinery in a modern plant producing 30 000 to 35 000 t of sheared plate per month is described. Conditions for obtaining first-quality products are pointed out.—R.P.

Fabrication of tubes for pipe-lines. III. Inspection and improvement of the processes H. Bouchon (*Soud. Techn. Connexes*, 1960, **14,** Sept.–Oct., 375–391) The production of tubes for conveying crude oil or gas under pressure is described, including the formation of U- an O-sections and submerged arc welding. The physical transformations of the material during these operations are discussed. Methods of inspection at different stages of the operation are pointed out. Improvements of the processes are studied.—R.P.

On the inductive longitudinal welding of pipes D. Kronauer and M. Thiele (*Schweissen Schneiden*, 1960, **12,** Dec., 525–530) The theories of fusion welding and of press welding are discussed with special reference to the production of longitudinally induction-welded pipes. The different structures obtained with the two methods are explained.—R.P.

Welding of galvanized steels M. Evrard (*Soud. Techn. Connexes*, 1960, **14,** Nov.–Dec., 437–448) Problems arising when welding galvanized steel sections and plates are discussed with special reference to changes in the zinc layer. Braze welding is shown to overcome these difficulties better than other joining processes (11 refs).—R.P.

Procedure in starting welding by the electro-slag method M. Mosný (*Zváranie*, 1960, **9,** (10),

290–293; (11), 326–330) [In Slovak] The technology of starting the welding process is discussed on the basis of recent work by the author and developments in the USSR.—P.F.

The practical application of electroslag welding B. Kjellberg (*Weld. Met. Fab.*, 1960, **28**, Sept., 347–356) The necessity for making a trial weld to determine the required conditions and electrode consumption are stressed. It is not possible to refill the spools during the weld and breaks in welding cannot be permitted for more than a few moments at the most; if longer, defects occur. The difficulties associated with the commencement are indicated, but when the process is under way the machine can be set at a constant welding speed and adjusted as required. Or it can weld in steps of approximately equal lengths. Some 23 examples are given in illustration and discussed and tables show plate thickness, electrode speed, welding and oscillation speeds, and depth of bath. With the thicker plates, a plurality of electrodes is used (4·4–6·2in require two) and an example is given of a well 18in thick in which the welding of a circumferential seam took 30 h with three electrodes, each spool of which carried about 1760 lb electrode wire. The welding of high alloy steel is satisfactory but a flux free from oxides must be used and voltage is lowered 15–20% for stainless materials. Certain precautions are stressed. Hardfacing can be carried out when large quantities of materials are to be deposited; a weld metal coating 2in thick of wear resisting steel can be deposited on C-steel at 3·3 ft/h without preheating and for the hard facing Cr–Mo, high-C Cr, W–Cr–V 18–4–1 high-speed steels and Ni-alloys can be deposited. Mn steels are less suitable because of the temp.—C.V.

The Vertomatic electro-slag process of welding S. G. Maine (*Eng. Found.*, 1960, **26**, Aug., 20–28) A brief description of the development and technique, followed by a general discussion.—C.V.

Welded steel cable drums and reels (*Welder*, 1960, **29**, July–Sept., 51–53) Heavy duty drums are available with dia. of from 3 to 18 ft with capacities up to 100 t. The flanges are made from folded sheet steel giving a high strength-to-weight ratio. The method of production is described and various drums are illustrated. Comparison with wooden drums is made and the difficulties associated with repair stressed. With the steel, flanges or barrels can be easily removed, straightened, replaced, and re-assembled. Such drums are also resistant to oils or other liquids which would be absorbed by wood.—C.V.

A new electron-beam welding unit W. J. Greene, R. R. Banks, and R. M. Niedzielski (*Weld. J.*, 1960, **39**, Aug., 791–796) The development of an easily controllable and reliable unit is described. It is pointed out that the complete absence of contamination gives this method great advantages for welding metals and alloys that are strongly reactive, such as Be, Mo, and W.

Novel system of marking welds Z. Dobrowolski (*Przeglad Spawalnictwa*, 1959, (7), 177–181; from *Polish Tech. Abstr.*, 1960, (37), 47) In his new system the writer aimed at dispensing with the drawing of weld joints, even complicated ones. He devised a system which by using short and simple symbols would obviate drawings of even very complicated welds and so be easy to introduce in both design office and machine shop.

Electron microscopical study on 'fume' produced in arc-welding H. Suemitsu and M. Kobayashi (*Suiyokwai-Shi*, 1958, **13**, Sept., 493–496) It is known that the harmfulness of the 'fume' produced in arc-welding is serious, particularly with a low-hydrogen type welding electrode. In this report, the appearance and the constituent of the fume is studied electron-microscopically along with the electron micro-diffraction method for the purpose of investigating the difference of the fume between the low-hydrogen type and other types of welding-electrode. NaF and CaF_2 are detected in the fume of the low-hydrogen type while that of the ilmenite type is composed almost entirely of Fe_2O_3 (however, fluorides are not the main cause of injuriousness). Their appearances also show a remarkable difference, notwithstanding the similarity of the particle size that is of the order of 0·1–1 μ.—R.S.F.C.

New alloys for welding electrodes Z. Misiolek, K. Joszt, and L. Gablankowski (*Przeglad Spawalnickwa*, 1959, (6), 149–154; from *Polish Tech. Abstr.*, 1960, (37), 31) The authors discuss the properties of electrodes made of the following new alloys devised by the Institute of Non-Ferrous Metals; Cu–Cr–Zn, Cu–Co–Be, Cu–Ni–P, and Cu–Ag. The method of manufacturing these alloys is outlined. Electrodes made of Cu–Ni–P may be used for welding carbon steels with etched surfaces while electrodes of a Cu–Ag alloy are suitable for welds of thick plates using high current intensities.

Weldment failure caused by fabrication and service H. Thielsch (*Weld. J.*, 1960, **39**, Nov., 1136–1144) The reasons for weld failures are itemized and discussed, and the necessary methods of control and inspection required to avoid these failures are considered.

The heat-affected zone of arc-welded ductile iron E. F. Nippes, W. F. Savage, and W. A. Owczarski (*Weld. J.*, 1960, **39**, Nov., 465s–472s This investigation was aimed at studying the effect of the cooling rate of various regions of a weld on the formation of martensite and massive carbides and the redeposition rate of carbon on existing graphite spheroids during cooling.

Weld strength and dimensional stability of cold-worked stainless steel L. Stemann and E. E. Weismantel (*Weld. J.*, 1960, **39**, Oct., 438s–442s) The value of the use of annealed-strength data for welded joints in cold-rolled steel is in question. In this work it was shown that such steel can be used at higher strength levels than the annealed strength data indicate, but more work is required.

Service failure of pipe weldments H. Thielsch (*Weld. J.*, 1960, **39**, May, 488–495) The drawbacks in customary inspection techniques are discussed, as are the bearing of design, material selection, specification, and handling on service.

Hot-cracking test for CO_2-shielded metal-arc welds P. W. Ramsey, R. A. Keidel, and J. N. Kuhr (*Weld. J.*, 1960, **39**, May, 219s–224s) A hot-cracking test has been developed, and is described. The origin of this type of cracking is discussed, and the beneficial effect of Mn, with no decrease in ductility, is stressed.

Web buckling tests on welded plate girders K. Basler, Yen Bung-tseng, J. A. Mueller, and B. Thülimann (*Weld. Res. Council Bull. Series*, 1960, Sept., (64), pp.63) An experimental and theoretical investigation on the dimensions and properties of these and the influence of bending, shearing and bending, and shear are reported in considerable detail. Some 150 tables, graphs, and illustrations are included (274 refs).—C.V.

Results and experience gained in tests on pipes with induction-welded longitudinal seams T. Furkel (*Schweissen Schneiden*, 1960, **12**, Dec., 517–525) Results of mechanical destructive and non-destructive testing on longitudinally-welded pipes are discussed. The structure of the weld is considered. Limitations of the process and advantages over seamless pipes are pointed out.—R.P.

Theory of adhesive joints Y. Kobatake and Y. Inoue (*Proc. Int Japan Congress on Testing Materials*, 1959, 156–158) The stresses in an adhesive butt joint are analysed.

Volatilization phenomena in high temperature brazing filler alloys W. Lehrer and H. Schwarzbart (*Weld. J.*, 1960, **39**, Oct., 449s–461s) Brazing alloys have been developed that are oxidation-resistant due to increase of remelt temp. The mechanisms by which this occurs, and the welding conditions necessary, are discussed. The compositions of various alloys are given.

Recent developments in oxy-fuel gas cutting C. C. Anthes (*Weld. J.*, **39**, Oct., 1022–1027) Methods of using C_2H_2 and natural gas in place of acetylene are discussed. Ways of avoiding excessively long preheat times, low cutting speeds, and poor cut quality are given in detail.

Oxygen profiler for Norway has automatic height control (*Brit. Eng. Transport*, 1961, **43**, Jan., 203–204) The height control system consists of a small electronic unit mounted on top of the machine with a remote hand-control switch which can be positioned at any point along the burner bar. There is one switch for each burner which can raise or lower it until it senses the height of the plate to be cut and the burner is raised or lowered by a fractional hp motor connected to a load screw in a fully-enclosed mechanism attached to the vertical slide of the machine. The various controls and adjustments are described. In the automatic position the burner descends and maintains the required height above the plate; it can move in either direction according to whether the plate undulates up or down. This unit can also be used for bevelling up to 45° either by angling the whole burner assembly so that the burner moves up and down in the line of the cut or by angling the burner only so that the burner moves up and down vertically; the probe ring is so designed that it can be kept approximately parallel to the plate surface. The fitting of this unit to an existing machine is also described.—C.V.

MACHINING AND MACHINABILITY

Plastic flow of the chip in steel cutting K. Okushima and K. Hitomi (*Bull. Jap. Soc. Mech. Eng.*, 1960, **3**, Nov., 556–560) [In English] Orthogonal cutting tests on carbon steel are described with details of cutting ratio, direction of structure flow, roughness of chip surface, etc., under various cutting conditions (rake, angle of tool, depth of cut, cutting velocity). The existence of a flow region, instead of a simple shear plane assumed in the conventional cutting theory, is advanced as proved by the difference between the measured and the theoretical angles of the inclination of chip flow.—S.H.-S.

The influence of oxidation on the machinability of castings (*J. d'Inf. Tech. Indus. Fonderie*, 1960, Oct., (120), 10–11) A very brief statement of the diagnostics of micrography with the causes of oxidation and their remedies.—S.H.-S.

New carbide for interrupted cutting Wickman Ltd (*Metalw. Prod.*, 1960, **104**, Sept. 28, 77–78) A new Wimet grade XL 35 carbide-tipped milling cutter, with a grain structure giving optimum resistance to flank wear and thermal cracking, which is claimed to be superior to conventional carbides, is described.—S.H.-S.

Improved carbide for milling steel Wickman Ltd (*Machine Shop Mag.*, 1960, **21**, Oct., 640–642) The use of Wimet tungsten carbide tipped milling cutters and their modes of wear and resharpening are described and illustrated. Thermal cracking is discussed and tests on the milling of crankshafts are outlined.

Physical properties of ceramic tool materials (Especially on the adhesion of ceramics) K. Okushima and Y. Fujii (*Bull. Japan Soc. Mech. Eng.*, 1960, **3**, Nov., 560–565) [In English] The adhesion of cutting tools at high temp. is described from the results of empirical cutting data and fundamental tests on the adhesion between cutting tool tips and work materials. The adhesion tests were run in a vacuum, except where noted by means of the Vickers hot hardness testing machine. Critical temp. for adhesion was found to be affected by the composition of ceramics and kinds of metals and the strength of the interface between ceramic tips and metals to be weaker than in the case of carbides, thus constituting one of the reasons why crater wear and built up edge in ceramics were less than in carbides.—S.H.-S.

The tungsten carbide rotary cutter J. D. Snow (*Prodn. Eng.*, 1960, **39**, Nov., 656–666) Design, production, and shaping are discussed at length.

Ceramic tools A. O. Schmidt (*Aircraft Prodn.*, 1960, **22**, Nov., 433–437) Properties, cutting tests, and economic factors are reviewed.

A new tooling compound Minnesota Mining and Manf. Co. (*Engineer Foundryman*, 1960, **28**, July, 41) A short description is given of a new tooling compound which has reduced by as much as 85% the time and material costs involved in tool making for the metal forming industry. The new two component (steel and epoxy type resin) punch and die material is designed for use in place of expensive machined metal tools for prototype or short run draws of difficult shapes.

Chemical cutting and grinding fluids P. W. Sherwood (*Austr. Mach. Prod. Eng.*, 1960, **13**, Nov., 21–23) The essential characteristics of four types of machine coolants, straight cutting oils, emulsions, and solutions, are briefly described.—C.V.

Hot turning superalloy (*Metal Prod.*, 1960, **104**, Nov. 23, 85–90) It is known that machining at elevated temp. improves the efficiency of metal removal and reduces tool forces and the amount of work done in cutting. A rise of 1000°F gives a reduction of 40–50% in cutting force and 33–66% in thrust force at the tool. The effects of raising the work 1000°F upon the mean tool-chip interface temp. varied widely with differing materials and the tool temp. are shown in parentheses; Thermold J (250–350°F), AISI 4340 (700–1000°F), 17–7 PH (300–700°F), and 17–4 MO (600–1100°F). Tool-life tests and cutting tool geometry are briefly reviewed and the necessary precautions attendant upon this form of machining are indicated.—C.V.

Cast irons have high machinability ratings (*Metalw. Prod.*, 1960, **104**, Sept. 14, 75) Two curves are presented showing that grey irons containing a coarse pearlite show a tool life twice that for fine pearlite iron, and a similar range of tool life for ductile irons, for all types of iron casting have essentially the same machinability with the same matrix structure.

Short-time test for the machinability of free-cutting steels by the weight-feed method H. Becker (*Stahl Eisen*, 1961, **81**, Jan. 5, 46–50) This test of machinability uses the pressure from a weight for feeding the support of a lathe, i.e. for cutting under a constant tool pressure. The advantage offered by this method is that it can be carried out with conventional machine tools with slight modifications only, whereas cutting-speed increase methods require special machine tools. The modification to the lathe is described and the selection of the correct weight discussed. Tests carried out showed that the method is extremely sensitive with respect to the machinability of the steels examined, for instance an impoverishment in the lead content in the outer layers of a steel rod was immediately detected.—T.G.

CLEANING AND PICKLING

Modernization of VEB Walzwerk Finow H. Grossmann (*Neue Hütte*, 1960, **5**, Dec., 730–733) A description of the project to extend the Finow mills, which will be equipped with jet descaling equipment and plant for the manufacture of welded tube and light sections.

Precise barrel finishing R. F. Enyedy (*Met. Fin.*, 1960, **58**, Sept., 65–68) Compounds for descaling, surface cleaning and polishing, the separation and drying of parts, and the control of barrel processes are discussed.—A.D.H.

Ultrasonic cleaning cuts service costs G. Spasink (*Foundry*, 1960, **88**, Oct., 195–198) The results of using ultrasonic cleaning equipment on hydraulic systems of coal cutting machines, mobile drills, etc., to remove contaminants, as compared with other methods, are described, and advantages in reduced operating costs are given.—S.H.-S.

Surface treatment of stainless steels. III G. Colombo (*Acciaio Inossid*, **27**, (5), 497–500) The writer describes surface, cleaning operations, treatment for the removal of oxide and scale including acid pickling with special reference to pickling of Cr–Ni and chrome steels.

An economic analysis of acid pickling vs. multiple strand blast cleaning of wire rod G. D. Gill (*Wire Wire Prod.*, **35**, Oct., 1311–1315, 1460) Costs are analysed and compared.—C.V.

Pickling of steel bars and wire rods Müller (*Chal. et Ind.*, 1960, **41**, Dec., 334–342) The writer describes the methods used to clean steel bars and wire rods in the following major categories. (1) Mechanical cleaning. (2) Cleaning by pickling or chemical methods.

Ni-o-nol meets sulphuric acid test: Pittsburgh Steel Company solves a fifteen-year-old problem (*Wiggin-Nickel Alloys*, 1960, (58), 14–15) Lining material for pickling tanks is described.

The challenge of spent acid J. E. Kinney (*Wire Wire Prod.*, 1960, **35**, Nov., 1541–1543, 1589) The problem is discussed.

Quality chain for pickling plant Parsons Chain Co. Ltd (*Wiggin Nickel Alloys*, 1960, (58), 21) Monel chain is briefly described.

Methods of treating used pickling solution J. Kapczynski (*Hutnik*, 1960, **27**, (6), 229–234) The author points out that in industry large quantities of used pickling agents are discarded into rivers with resulting pollution and waste. He goes on to outline methods of reclamation. These are of two types: neutralization with formation of a by-product of commercial value or regeneration of the constituents.

How to clean stainless steel R. E. Paret (*Inco-Mond Magazine*, 1960, (15), 24–27) A guide for the food and catering industries in particular.

Relative cleanability of various stainless steel finishes after soiling with inoculated milk solids O. W. Kaufmann, T. I. Hedrick, I. J. Pflug, C. G. Pheil, and R. A. Keppeler (*Journal of Dairy Science*, 1960, **43**, Jan., 28–41; reprint, pp.14) Various washing procedures were used and assessed bacteriologically.

Cleaning of carbon steel wire and the metallurgical nature of the scale A. B. Dove (*Wire Wire Prod.*, 1960, **35**, Nov., 1547–1554, 1589) The theory of scale formation is examined; the material is considered to be in a state of compression. It is shown that time increases film thickness according to a parabolic relationship while with temp. it is exponential. The rates of solubility are considered since the Fe_3O_4 layer is relatively insoluble in H_2SO_4 and thus the acid cannot reach the soluble FeO layer readily. It is considered that mechanical descaling is less effective than chemical but that this can be improved by lowering the reeling temp. and then accelerating the cooling to black heat by air and water.—C.V.

Finishing stainless steel the 'Electropol' way P. A. Charlesworth (*Prod. Fin.*, **13**, Oct., 86–87) A brief note on the development of the Electropol process for polishing stainless steel in the 12 years since 1948 and the prospects for large-scale extension in the field of stainless steel architecture.—S.H.-S.

Lifetime testing of metallic blasting shot P. U. Schmithals and H. G. Labisch (*Stahl Eisen*, 1960, **80**, Dec. 22, 1939–1944) The various methods in use for testing the service life of shot are reviewed and the sources of errors met with in sieve analyses are pointed out. The authors suggest another method that avoids the use of sieve analyses. They count the number of passes until the number of shot grains has doubled. They found that there is a linear relationship between the results obtained in the short-time tests and in actual service tests.—T.G.

Taking the pressure off tumbling K. W. Horton and E. N. Gould (*Metalw. Prod.*, 1960, **104**, June 15, 170–171) Two simple devices developed by Watervliet Arsenal, Watervliet N.Y., to overcome tumbling problems—an automatic gas vent, and a non-clog media gate —are described with diagrams.—S.H.-S.

PROTECTIVE COATINGS

Choice of protective schemes for structural steelwork F. Fancutt and J. C. Hudson (*Inst. Civil Eng. Prod.*, 1960, **17**, Dec., 405–430) Recent developments and current views are presented with special emphasis on schemes for atmospheric structures. The necessity of correct design in order to reduce the risk and severity of corrosion is stressed and preparation of surfaces is reviewed. Various types of protective coating, especially metal coatings and paints, are examined. (31 refs).—C.V.

Protective coatings for corrosion control in production operations R. M. Robinson (*J. Petroleum Techn.*, 1960, **12**, Oct., 20–24) A table of coatings classified as metallic, bituminous, plastic, and oleoresinous with general properties and costs is given with a discussion of petroleum industry equipment and its protection.

Surface protections for iron castings (*Fonderia*, 1960, **9**, Nov., 481–485) Various methods of coating and plating are described including metallic spray coating, immersion coating, galvanizing, zinc sulphate bath, Cu, Cr, Ni, and Al plating, sherardizing, chromizing, Cd plating, and coating by case hardening.

Barrel plating F. J. Le Manna (*Met. Fin.*, 1960, **58**, Sept., 52–55; Oct., 66–70) A general survey is made of the electrical efficiency and power requirements, preparation, and the techniques used in barrel plating. Solution compositions and plating procedures are given for 13 common metals.—A.D.H.

Stress in electrodeposited metals I. L. Newell (*Met. Fin.*, 1960, **58**, Oct., 56–61) The effort of residual stress and its measurement in Cu, Cr, Zn, Pb, Cd, and Ni deposits are reviewed.

Metal rectifiers for electrolytic processes J. G. Bartholomew (*Met. Fin. J.*, 1960, **6**, Nov., 432–436) Past and present developments in rectifiers are briefly reviewed.—C.V.

Science for electroplaters. 59. Causes of poor adhesion L. Serota (*Met. Fin.*, 1960, **59**, (8), Aug., 60–63; (9), Sept., 69–72; Oct., 72–73, 79) The influence of polishing, pickling surface condition, and surface films is reviewed. Methods of improving adhesion of electrodeposits on chromium alloys are considered.

Adsorption of cyanide ions on weakly basic anion exchange resins G. Gabrielson (*Met. Fin. J.*, 1960, **6**, Nov., 430–431, 441) It was found that the free cyanide content of Cu plating solutions could not be determined by adsorption of the Cu–CN complex ions on a weakly basic anion-exchange resin. The details of the experimentation are given.—C.V.

Finishing pointers. How current efficiencies affect solution control E. F. Duffek (*Met. Fin.*, 1960, **58**, Oct., 71) Anode and cathode efficiencies of common electroplating solutions are tabulated and their values are used to explain the changes in pH and metal content that occur in use.—A.D.H.

Mechanical plating D. E. J. Cunningham (*Met. Fin. J.*, 1960, **7**, Aug., 305–308) Some details of the Peenplate process are given. This method is used for the coating of small hardware with Zn or other soft metal without the use of electricity and is a process of cold welding employing a modified barrel-finishing technique. Coatings can be applied to many non-ferrous metals and even to ceramics. The essential equipment is the tumbling barrel; this must be rubber lined and hexagonal or octagonal to give the necessary action; barrels should have a variable-speed drive as rate of rotation is one of the variables which can affect the final coating. Parts must be cleaned and degreased; a very thin Cu coating and a slight etch should be given. Impact material may be spherical or irregular, metallic or fused alumina, and glass. The metal powders should be of the finest particle size; spongy or leafy are undesirable as surface area/wt ratio is high and oxide concentration is therefore also high. Details are given as to batch sizes, additives, etc. With washers, the paste coating deposit is completed in ~5 min and complete consolidation in 15–20 min; further running for 5 min is given to obtain a brightly polished effect. Over-running tends to chip the coating.—C.V.

The analysis of gas in electrodeposited metals K. Nishihara and Y. Matsumura (*Suiyokwai-Shi*, 1955, **12**, June, 533–536) Analysis by vacuum extraction of iron and other metals was carried out. Iron was extracted for 1½–2 h at 800°C. Mainly H_2 is evolved, special precautions against the admission of moisture are required.

Electroplating nickel-chromium and copper on iron castings (*Fonderia*, 1960, **9**, Nov., 472) A brief description is given of the three types of electroplating.

Electrodeposition of nickel–tungsten alloys from a pyrophosphate bath K. I. Vasu and T. L. Rama Char (*J. Sci. Ind. Res.*, 1960, **19B**, Oct., 413–414).

Zinc coatings J. H. Nicholls (*Prod. Fin.*, **13**, Oct., 58–66) A comprehensive review of the common zinc coating processes describes hot dipped galvanizing, electrodeposited zinc coatings, sherardizing, the use of zinc-rich primers, zinc spraying, and peen plating. The extension of the life of a zinc coating by an organic finish is briefly discussed.—S.H.-S.

The effect of hot dip galvanizing and aluminizing of steel wire on properties of the coatings S. Socha (*Prace Inst. Hutn.*, 1960, **5**, (12), 239–247) Tests were made of galvanizing and aluminizing of steel wires annealed in a H_2 atmosphere. The best conditions for reduction of scale were: annealing temp. 900°C and

reduction time 30 sec. The effect was studied of time and temp. of galvanizing and aluminizing on thickness, tightness, and corrosion resistance of the coatings and on structure and mechanical properties of coated wires. It was established that by the use of reducing atmosphere in galvanizing and aluminizing steel wire expensive acid pickling can be eliminated and good zinc coatings obtained.

The Metalliss high-temperature galvanizing process (*Product Fin.* 1960, **13,** Aug., 101–103) An eight stage plant with optional phosphating is described with modifications in zinc bath additives and in pickle solution. It is especially useful for bolts.

The application of electrical engineering principles in a modern tinplate industry J. Nelsey (*S. Wales Inst. Eng.*, Advance Copy, 1960, 1–23) Electrical principles are outlined including rectifier theory.—C.F.C.

World annual tinplate production climbs toward 10 m tons through thick and thin (*Tin*, 1960, Nov., 284–287) This is analysed by countries and tabulated over the 1950–1959 period; the first six months of 1960 is also included and attained 4 768 000 t.—C.V.

The tinplate industry W. J. S. Roberts (*Metallurgist*, 1960, **1,** Nov., 208–214) A brief review of the process with illustrations.—C.V.

Low friction coating: works best at 600–1200°F (*Mat. Des. Eng.*, 1960, **52,** Sept., 9) PbO provides a low friction coating which can function up to the indicated temp. and it is applied like a porcelain enamel to stainless steel 440C and to 304, and to Inconel X. The addition of 5%SiO_2 and 5%Fe_2O_3 gives excellent results, the iron oxide being absorbed from the steel during the firing. Coatings are applied as a dry powder or sprayed as a water slurry; firing takes place at 1650–1800°F and such fired-on films give lower friction coefficients at temp. >600°F than commercial resin-bonded MoS_2 coatings. At sliding velocities 2400–10000 fpm friction coefficients were 0·05 to 0·08 within the temp. range studied. It is considered that a glazed or vitreous surface is formed by the PbO in the zone of sliding and therefore this takes place by plastic or viscous shear rather than by a shear along the crystal planes. The life of these coatings depends on temp. attaining a max. at 1000°F, and decreases slightly at 1250°F.—C.V.

Progress toward the development of a non-embrittling cadmium electroplating process. IV. Use of methanol as a solvent in cadmium plating solutions S. W. Strauss and P. N. Vlannes (*Plating*, 1960, **47,** Aug., 926–932) Noncyanide baths containing methanol or methanol plus triethanolamine were investigated over a wide range of composition for their characteristics in plating Cd on ultra-high-strength steel. Plating evaluation included Hull-cell data, throwing power and current efficiency determinations, embrittlement characteristics, and bath life in continuous plating. Results of delayed fracture tests indicate that the methanol and methanol-triethanolamine baths are nonembrittling.—S.H.-S.

Metallizing steel wire by immersion in molten aluminium K. Janecky (*Met. Fin. J.*, 1960, **6,** Aug., 309–312, 319; from *Hutník*, 1960, **10,** (2), 61–64) Metallizing with Al is very similar to Zn but it is suggested that with Al greater technical care has to be exercised. Three methods are considered, (a) aqueous solution of flux, (b) flux in the form of a salt solution, and (c) use of a reducing atm instead of flux. The first is the simplest and most efficient but the second both on account of plant and technique presents several difficulties; however, since the salt fluxing bath can also be used for heating, the aluminizing is speeded up very considerably. The use of a reducing or inert atm is a great simplification, also resulting in increase of efficiency. Commercial Al can be used for the bath but the coating normally produced has inadequate bend properties due to the thickness of the Al_3Fe phase, but decreasing this gives an unsatisfactory product. Alloying with Si improves the quality although Be and Ti are more effective. Other problems are outlined and discussed.—C.V.

Metal alloy spray coating development resists acid and alkali conditions (*Corros. Techn.*, 1960, **7,** Sept., 278–279) It is shown that the development of a Zn–Al alloy, Berkalloy, for spraying has considerably increased the range of application of the metals when used separately.

Protection against corrosion-sprayed metallic and plastic coatings J. H. Nicholls (*Corros. Techn.*, 1960, **7,** Sept., 275–277) The range of metals, plastics, and procedures available are briefly reviewed and compared.

Thick vacuum-metallized coatings are durable, corrosion resistant P. J. Clough and H. M. Farrow (*Mat. Design Eng.*, 1960, **52,** Sept., 12–15) This new evaporation method has so far been confined to Al-coatings for special purpose steels such as 8740 H–11, and Vascojet. It has also been used for cold rolled steel, including stampings, cast iron, Ti, and wrought and die-cast Al and Mg alloys. The use of Al coatings over Al-alloys is specially interesting but vacuum metallized coatings have the advantage that they can be applied to complex shapes. The problems associated with evaporation are discussed; the method used is similar to the continuous and semi-continuous coating of plastics foils and paper. Coatings 1 mil thick can be applied in 5 sec in the laboratory but commercially 3 min is advised. The use of Cd, W, carbide, and oxide coatings is also discussed and a general résumé of vacuum metallized coatings is included.

Add plastics to corrosion foes F. Arne (*Chem. Eng.*, 1960, **67,** Oct. 17, 104, 106, 108) US demand for reinforced plastics, their compositions, and uses, are outlined. Polyesters are mainly considered but other plastics are mentioned.

The development of the coating of steels with plastics F. Wiesner and M. Zezulova (*Hutn. Listy*, 1960, **15,** (9), 694–699) American, Belgian, British, German, and Swedish processes of coating steel strip and sheet with PVC are surveyed.—P.F.

Metal protection and lubrication—improved organic chemicals J. K. Aiken and S. W. Critchley (*Metallurgia*, 1960, **7,** Sept., 281–282) The more recently developed organic chemicals in metal protection and lubrication are discussed with particular reference to their use in preventing corrosion.

Enamelling properties of cast irons (*Fonderie*, 1960, Sept., 392–393) The effect of small quantities of Ni, Cu, and Cr on liquid or powder methods of enamelling cast iron is discussed The importance of preparing the metal surface prior to enamelling is stressed. Pickling is not recommended if a liquid enamel is applied.

Steel sheets for single coat porcelain enamelling R. S. Burns and R. L. Myers (*AISI Preprint*, 1960, pp.16) Sheet steel for single coat enamelling must be free from any tendency to fish scale. The three conditions are, controlled C-content in the ingot, coiling temp. of the hot band sufficiently high to form massive carbides, and adequate cold reduction to produce microscopic voids. In addition, the sheet must be free from enamel boiling tendencies due to C and this is achieved by complete decarburization. To attain satisfactory bending, the metal surface must be microscopically roughened and this is best achieved by attack with oxidizing acids. By using a high grade sheet and a good single coat, the blue ground coat and firing can be eliminated with reduction in cost.—C.V.

Corrosion concepts for glassed steel D. K. Priest (*Am. Ceram. Soc. Bull.*, 1960, **39,** Oct., 507–510) Testing methods are given and resistance to acids and alkalis are noted. All acids but HF and H_2PO_4 can be used in glass-enamelled steel up to 300°F. Solutions at pH12 can be handled up to 212°F. Concentrated alkalis can be used below 100°F. Water has little effect below 200°F.

Coating and lining against corrosion: experience in plant trials Wolseley Holdings Ltd (*Corros. Techn.*, 1960, **7,** Sept., 293–294) Notes of three years experience of the use of the Lanshield Sakaphen phenolic, epoxy-type, polurethane, etc., coatings in plant trials.

Low-pressure enamel spraying technique—material waste and time reduction T. B. Vaughan (*Corros. Techn.*, 1960, **7,** Aug., 254–247) The use of new techniques to avoid excessive losses due to overspray is described, and the possibilities of motion study in connexion with the use of spray guns are examined.

Lead based priming paints for iron and steel (*Lead News*, 1960, **1,** May, 4–6) A general account of red lead, metallic lead, and calcium plumbate primers.

Steel pretreatment and priming—rust prevention with new system prior to stove enamelling N. R. MacCleaster (*Corros. Techn.*, 1960, **7,** Sept., 284–286) A hot-spray system developed by MacCleaster Chemical Co. Ltd for applying Zn to metal is described, which eliminates the usual phosphating operation and does not require de-rusting.

CLAD SHEET AND HARD FACING

Hard surfacing lengthens service life in continuous centrifugal filtration machine Wall Colmonoy Corp. (*Weld. J.*, 1960, **39,** Aug., 813–814) The application of hard surface coatings, and the benefits derived from them, are discussed.

Mechanized hard surfacing cuts costs 48% Haynes Stellite Co. (*Weld. J.*, 1960, **39,** Aug., 816) An application is described in which mechanized hard-surfacing increased production and cut costs, and comments are made on types of operation that would benefit likewise.

Make your hard-facing electrode to order—on the welder (*Metalw. Prod.*, 1960, **104,** Sept. 28, 85–86) A new Soviet powder-filled tape electrode, replacing filled welding rods, is reported, which is claimed to be suitable for submerged-arc, automatic, or semi-automatic metallizing. Coils feed twin steel strips (lower one corrugated to hold metallic powder) into squeeze rolls. C–Mn–Si–Cr–iron powder flows through a gate into the lower strip, constituents being varied at will to meet requirements of the work and metal to be treated. The claim is made that the same style electrode cut into convenient (18in) lengths can be used for manual hard facing.—S.H.-S.

The development of Co–Cr–Mo–W hard-surfacing alloys for operation around 700° C. K. Löbl (*Zváranie*, 1960, **9,** (11), 320–326) [In Czech] The development and properties of alloys of high thermal shock resistance for steam turbines working at temp. around 700°C is described. Of the 12 new alloys studied, some were found to be superior to similar Stellites in repeated-impact tests. Long-time tests are now in progress.—P.F.

Russian hard-facing process (*Commonw. Eng.*, 1960, **48,** Oct. 5, 48) A process for producing an electrode with a hard alloy facing by using a cellular strip enclosing a powder is briefly described.

POWDER METALLURGY

Fundamental studies on pressing of powder by means of hydrostatic pressing method. (Studies on pressing of TiC–Co system Cermet No.1) C. Kawashima, S. Saito, and M. Kato (*J. Japan Soc. Powder Met.*, 1958, **5,** Aug., 18–25) A study of compaction by hydrostatic pressure in a rubber die is reported. TiC–Co powders were used and green strength was determined.

Fundamentals of sintering. IV. Fourth annual progress report covering period July 1, 1958, through June 30, 1959 J. Brett, L. S. Castelman, and L. Beigle (*SEP*–254, 1959, June, pp.33; from *US Res. Rep.*, 1960, **33,** Jan. 15, 103) (No abstract).

Sintering of iron powder compacts. I. Effect of powder characters on connected and sintered bodies T. Nishijima (*J. Japan Soc. Powder Met.*, 1958, **5,** Oct., 97–106) Powders produced by different methods, were compared for particle shape, size, and composition, and their effects on sintering were studied, especially the effects of particle form.

I. Sintering of iron powder compacts. 2. Sintering with reducing oxide or slightly pre-oxidized powder compacts T. Nishijima (*J. Japan Soc. Powder Met.*, 1959, **6,** Feb., 19–24) Generally speaking, the decomposition of metal oxide to metal and O_2 is endothermic while combustion of H_2 or CO is exothermic. These changes as well as the converse, are studied as well as the effect of slow or rapid heating, flow rate, gas pressure, and furnace atm. (CO_2, CO, H_2O, and H_2), on the microstructure.—C.V.

Some effects of atmosphere on the sintering process of iron–carbon compacts K. Hijikata

and Y. Tajima (*J. Japan Soc. Powder Met.*, 1960, **7**, April, 49–57) A series of Fe–C mixtures with various graphite contents were compacted under various pressures and the effects of moisture are reported. It was found that less shrinkage occurred when graphite was present as compared with that obtained with pure Fe while a higher shrinkage was noted in moist H_2-atm. Wt continued to decrease to 900° due to degassing, loss of moisture, and reduction of of surface oxide. Carburization was little influenced by compacting pressure; moisture content in H_2 however resulted in marked carbide formation; the depth of the decarburized layer reached 1·6 mm. With decreasing moisture, carbide formation was reduced and much C was left uncombined, the decarburized layer being very thin. High strengths were obtained with high compacting pressures with 1% graphite and 1·7–1·9 mg/l moisture content. The relationship between strength and internal/external structure is discussed in relation to the degree of carburization and the uncombined graphite.

Sampling of metal powders K. Akabane and S. Yashima (*J. Japan Soc. Powder Met.*, 1958, **5**, Oct., 85–96) A double core-mixer was constructed and sampling was treated statistically. A standard has been drawn up from the findings.

Uniform, spherical powders of metals and alloys gives controlled porosity and other processing advantages Union Carbide Co. (*Mat. Design Eng.*, 1960, **52**, Sept., 10) A method of producing such powders with uniform particle sizes ranging from 20–150μ is discussed; they are formed in a totally inert atm and are free from such defects as voids, cavities, and inclusions; uniformity is claimed to be 98%. Cu, Al, Ni, 316-stainless steel, W, and Nichrome have been produced in this form and others are promised. Details of the process are not available but $\frac{1}{8}$ in dia. wire of uniform cross-section and free from impurities is used as a starting material. Various potential applications are summarized.—C.V.

Effect of porosity on the structure of sintered metals H. H. Hausner (*J. Japan Soc. Powder Met.*, 1960, **7**, April, 58–72) The variables associated with porosity are examined, total pore volume, total number of pores, total number of closed pores, total volume of interconnected pores, pore size, and distribution, average pore size and shape, the orientation, gas content, and activity of the pores and their relationship to grain boundaries. An equation is given interrelating these factors and this is applied to the sintering of pressure-compacted, deformed, and undeformed powder particles. It is shown that pores in metal powder compacts affect grain boundary movements just as solid inclusions do and the bond between grain boundary and a void depends on the pore shape. Before spheroidization of the voids, the grain boundaries will stick to the voids; after, the grain boundaries move away. Oriented porosity may give rise to oriented grain structure. It is suggested that a complete knowledge of the interrelationship of these several factors will allow sintered materials to be produced with special physical characteristics.—C.V.

Sintered iron–copper alloys for machine parts K. Watanabe, K. Fujii, and E. Hayashi (*J. Japan Soc. Powder Met.*, 1958, **5**, Dec., 147–158) Studies on the sintered iron-base alloys for machine parts are still going on. This is a report covering the properties of iron–copper sintered alloys and a discussion on several problems as follows: (1) Effects of the iron powder distribution on dimensional changes of sintered compacts. (2) Effects of the copper content on the properties of the sintered compacts. (3) On the properties of sintered compacts made by a repressing method: (4) On the properties of sintered compacts using electrolytic or reduced iron powders; (5) On the precipitation-hardening of sintered compacts; (6) On the gas-carburization of sintered compacts.—R.S.F.C.

Some properties of sintered iron as machine parts material E. Hayashi, K. Watanabe, and K. Fujii (*J. Japan Soc. Powder Met.*, 1958, **5**, Aug., 26–36) Green and sintered compacts made by single or multiple pressing methods were examined. Carburization trials in town gas or with charcoal were also made.

Powder-metal parts used in Soviet tractors (*Metalw. Prod.*, 1960, **104**, Sept. 21, 78–79) Developments arising out of the making in 1958, of 17 tractor parts and a number of other components made of metal powders at the Stalingrad tractor works with economies in labour, production costs, and metal, from the use of a combined dosing and pressing automatic machine, followed by sizing in special tooling in a conventional press are described with details of composition and properties of powder metals and diagrams of equipment.

On the magnetic properties of sintered iron compacts T. Fujiyama (*Sumi Met.*, 1960, **12**, Jan., 347–354) Data are given for the magnetic properties of sintered compacts made under various conditions from powders produced by (a) electrolytic stamping, (b) reduction, (c) atomizing, and (d) eddy-mill pulverizing. In general, properties are improved by increase of sintered density. For max. permeability, the best and worst results were obtained from powders (a) and (d), respectively.—K.E.J.

FERRITES, CERMETS AND CARBIDES

On the sintering of ferrites T. Takei, M. Sugimoto, and S. Sekiguchi (*J. Japan Soc. Powder Met.*, 1958, **5**, Oct., 80–84) The effect of particle size on the properties of sintered ferrites was studied and related to ball milling time. Density increased with degree of grinding but density changes on sintering are irregular.

Effect of potassium ions on the final properties of Mn–Zn ferrite S. Makolagwa (*Acad. Polonaise Sci., Bull. Tech.*, 1960, **8**, (9), 543–545) Ferrite with a composition of 53%Fe_2O_3, 29·4%MnO, and 17·7%Zn has been studied with and without the addition of 0·01–3·0 mol%KCl. Experimentation showed that oxidation and reduction processes were accelerated by the presence of K-ions. During calcination at 1200°, ~70% of the K volatilized from the ferrite and in the final sintering almost all the remainder was liberated; this was confirmed by photometric analysis. The effect of oxidation and reduction on the magnetic properties of the ferrite is discussed. It is considered possible that during the volatilization the K creates additional holes in the lattice and that this speeds up defect formation the lattice being thus more sensitive to redox changes.—C.V.

The effect of cation vacancies on the magnetic annealing of $Co_xFe_{3-x}O_4$ T. Inoue, H. Mizuta, and S. Iida (*J. Phys. Soc. Jap.*, 1960, **15**, Oct., 1899) [In English].

Oxygen-rich manganese ferrite solid solutions A. Braginski *Acad. Polonaise Sci., Bull. Techn.*, 1960, **8**, (9), 533–536) Surface oxidation of Mn-ferrite solid solutions, $Mn_xFe_3O_{4+y}$, at temp. <600° leads to the formation of O-rich compositions with a defective spinel lattice where $y \geqslant$ approx. +0·35. These solutions have not previously been described and their crystal lattice becomes more inverse as the O-content increases. The high Curie temp., >400°, is of interest.—C.V.

On the formation of zinc-ferrite I. Kushima, T. Amanuma, and A. Fujiwara (*Suiyokwai-Shi*, 1955, **12**, March, 413–416).

Dissociation pressures of solid solutions from Fe_3O_4 to 0·4 Fe_2O_3: 0·6 Fe_2O_4 R. E. Carter (*J. Am. Ceram. Soc.*, 1960, **43**, Sept., 448–452) Within the limits of experimental error, it is concluded that solid solutions as indicated are thermodynamically ideal but there are indications that the dissociation pressure rises sharply at high concentrations of $CoFe_2O_4$. Up to 60% mole $CoFe_2O_4$, the mixed ferrite acts as a quasi-binary system as determined by its behaviour in a displacement reaction in a galvanic cell (14 refs).—C.V.

Oxygen mobility in polycrystalline $NiCr_2O_4$ and α-Fe_2O_3 W. B. Kingery, D. C. Hill, and R. P. Nelson (*J. Am. Ceram. Soc.*, **43**, Sept., 473–476) O_2, containing ^{18}O, has been used to determine diffusion coefficients by mass spectrometric analysis. In $NiCr_2O_4$ it is represented by $D = 1 \times 0{\cdot}017_e(-65400/RT)$ and in α-Fe_2O_3 by $D = 1 \times 10^{11}{}_e(-148000/RT)$. The large difference between D_o and the activation energy for these materials suggests that different mechanisms are involved (14 refs).

Study on the OP magnet (1st report). Influence of solid state reaction on sintering of the ferrite magnet H. Nakamura, N. Kawai, and K. Kudaka (*J. Japan Soc. Powder Met.*, 1958, **5**, Dec., 159–161) Mechanism of sintering of the ferrite magnet (OP magnet) is investigated. Mixed powder of several metal oxides and ferrite powder are both sintered, measured in changes of shrinkage porosity and intensity of magnetization with sintering and compared with each other. As results, the sintering process of a ferrite magnet takes three stages: (1) Reaction and sintering, both proceed rapidly; (2) Reaction proceeds slowly and sintering ceases; (3) Reaction comes to an end, but sintering proceeds again. Finally the cause of the sintering process in the 2nd stage is discussed and considered to be the effect of solid state reaction.—R.S.F.C.

PROPERTIES AND TESTS

Practical steel plant research K. L. Fetters (*AISI Preprint*, 1960, pp.19) Some examples of 'unpublicised' steel plant research are given. These relate to electrolytic tin lines, the development of high strength electric-resistance weld line pipe, the problem of defective welds, and 'hot tear' cracks, the occurrence of structures composed of high temp. transformation products which affect weld zones, the production of a continuous magnetic particle device to act as a continuous production non-destructive tester, the relationship between the Bauschinger effect and plastic strain causing it, etc.—C.V.

Research on the mechanical properties of metals (*Austr. Mach. Prod. Eng.*, 1960, **13**, Oct., 23, 25, 27) A brief review of work by the NBS (15 refs).—C.V.

On the method of preparation of high purity iron and its alloys H. Nishimura and Y. Murakami (*Suiyokwai-Shi*, 1954, **12**, July, 341–348) In order to prepare high purity iron and its alloys, electrolytic iron was melted in a high-frequency induction furnace and a stream of purified hydrogen passed over the surface of the liquid metal to remove oxide, and then purified alloying element was added. The relation between microstructure and oxygen content was investigated. This method is also applied to the preparation of oxygen-free high-purity copper.

Application of digital measuring methods to metallurgical technology and research H. Knüppel and W. Dorr (*Stahl Eisen*, 1961, **81**, Jan. 19, 73–88) The advantages offered by digital systems—the presentation in digital form is simpler and is easier to adapt to logic operations—are explained and some examples of application are discussed; for instance the limestone addition in the basic converter process, and the weighing machine attached to a ladle crane. The latter also allows the pouring rate to be determined. The method is also useful in thermodynamic analysis in the laboratory.—T.G.

Studies on austenitic manganese steel castings S. Miyazaki (*Suiyokwai-Shi*, 1958, **13**, Sept., 478–481) Mechanical, wear-abrasive properties and work-hardenabilities of austenitic manganese steel castings containing 0·68–1·78%C, 8·44–12·46%Mn were investgated. Test pieces were cast in sand moulds or chill moulds and quenched from 1050°C. Wear abrasion tests were carried on in the testing apparatus in which test-pieces were abraded on a horizontal rotating grinder wheel. The results obtained were as follows: mechanical properties were best with a ratio Mn/C=10, but wear-abrasive properties were best with Mn/C<10. Wear abrasive properties in chill castings of a composition Mn–C=7·5–10 were better than those that had composition Mn/C>10. Even austenitic manganese steel castings with relatively low Mn content had quite good work-hardenability.—R.S.F.C.

Influence of the distribution and the nature of small slag inclusions on the strength of cast steel B. Matuschka (*Rev. Mét.*, 1960, **57**, Nov., 999–1001) The use of a high-frequency furnace for melting steel led to the formation of lines of slag inclusions at the primary grain boundaries, derived from the felspar lining. These

cause a lowering of mechanical properties, especially of the elongation. The trouble was eliminated by the substitution of a quartz lining.

Investigation of significant properties and characteristics of cold worked steel: a comparison of the mechanical properties of cold drawn steel bars with a heat-treated 4410 steel bar (*WAL*–310/90–8; *PB* 143759, 1953, Jan., pp.17; from *US Res. Rep.*, 1960, **33,** Jan. 15, 81) This steel, heat-treated to 132 000 lb/in² tensile strength, showed higher mechanical properties in tensile, V-notch Charpy, and notched tensile tests, compared with cold-worked steels.

Investigation of significant properties and characteristics of cold worked steel (*WAL*–310/90–8; *PB* 143760, 1948, Aug., pp.46; from *US Res. Rep.*, 1960, **33,** Jan. 15, 81) Variations in rate of change in mechanical properties with amount of reduction, and the effect of variables such as C content and heat treatment before cold working on rate of change are investigated (29 refs).

On stress measurements of the Ogiwara Bridge T. Fukuda, K. Kubo, and T. Nakamura (*Procs. of the Symp. on the Stress Measurements for Bridge and Structures. Japan Society for the Promotion of Science*, 1957, Dec., 1–9) [In English].

Stress measurement of the new Fujikawa railway bridge K. Tomonaga, T. Nishimura, K. Yasunami, T. Shiraishi, and H. Kurokochi (*Procs. of the Symp. on the Stress Measurements for Bridge and Structures. Japan Society for the Promotion of Science*, 1957, Dec., 10–55) [In English].

On measurement of stress (2nd Report). Temperature distribution in members and vibration characteristics of the Inoura narrow bridge (Saikai-bashi) E. Murakami and I. Yoshida (*Procs. of the Symp. on the Stress Measurements for Bridge and Structures, Japan Society for the Promotion of Science*, 1957, Dec., 56–64) [In English].

Maximum stress-cycle counter Y. Tada and Y. Yamamoto (*Procs. of the Symp. on the Stress Measurements for Bridge and Structures. Japan Society for the Promotion of Science*, 1957, Dec., 78–89) [In English].

Investigation on the stresses and vibrations of the crane girders T. Tsukamoto, M. Kawamura, K. Kawashima, H. Umemura, and K. Kanai (*Procs. of the Symp. on the Stress Measurements for Bridge and Structures. Japan Society for the Promotion of Science*, 1957, Dec., 90–101) [In English].

Experimental study on the steel girder which is connected to the slab by the slab connector M. Naruoka, I. Hirai, and H. Shimizu (*Procs. of the Symp. on the Stress Measurements for Bridge and Structures. Japan Society for the Promotion of Science*, 1957, Dec., 102–108) [In English].

Influences of rope pitch on the mechanical properties of wire rope (2nd report) E. Mikumo, T. Aida, K. Asaoka, and S. Omori (*Suiyokwai-Shi*, 1954, **12,** (5), 205–208) Influences on properties such as breaking strength, modulus of elasticity, flexibility, maximum bending stress, and twisting mode were measured and are discussed, referred to 19 wire spiral ropes of three different pitches.

The new German standards on surface roughness and their effects on surface measurement H. von Weingraber (*Stahl Eisen*, 1960, **80,** Dec. 22, 1933–1939) The changes which have been made in the definition of surface roughness in the new German standards DIN 4760 and DIN 4762 Blatt 1–3 are discussed and the merits of the various systems used reviewed. The need for testing instruments that conform with the new standards is stressed.—T.G.

Measuring the roughness factor of a small steel disc C. Begovich (*ASTM Bull.*, 1960, Sept., 56–57) The necessity for being able rapidly and accurately to determine the lamination factor in small steel specimens is stressed. If this factor is low, the effect is not felt till the lamination steel is made up into a rotating electrical part and the difficulties in determining this factor are noted. In the present communication, the roughness factor is defined as the actual volume of a metal multiplied by 100 and divided by the calculated volume. From this an equation is obtained in which the lamination factor represents the correlation between the the roughness and lamination factors. This method has been in use for almost a year and has brought about a significant reduction in the variation in lamination factor. The preparation and testing of specimens and the interpretation of results is discussed.—C.V.

Specimen collection for controlling surface roughness in engineering production V. Odvody (*Czech. Heavy Ind.*, 1960, (10), 15–20) Standard series of finished metal surfaces are described with mode of classification and methods of observation.

The role of the non-uniform elastic deformation of the microvolumes of carbon steel when hardened by cold plastic deformation A. V. Gur'ev (*Izvest. VUZ Chern. Met.*, 1960, (1), 72–76) When hardening steel by plastic deformation there appears a resistance to the propagation of the microdisplacements in the elastic domain acted upon by the applied loads. The growth of stresses of the 2nd order is the direct consequence of the hardening of the alloy under plastic deformation. A direct relation has been found between the variations in the modulus of microplasticity and the increase in hardness.

The effect of the stress system on the hardening of the microvolumes of a polycrystalline alloy under cold plastic deformation A. V. Gur'ev (*Izvest. VUZ Chern. Met.*, 1960, (2), 53–56) One method of increasing the strength of metals is cold plastic deformation. X-ray investigations have shown that this operation is accompanied by an increase in the stresses of the second and third orders and by a fragmentation of the blocks. The experiments here described have shown that under plastic torsion and stretch the modulus of microplasticity increases with an increase in the plastic deformation. This shows that cold plastic deformation increases the resistance of the microvolumes of a polycrystalline alloy to the occurrence of micro-displacements and to their expansion. Further study is needed to elucidate the role of the surface layer of the metal and its effect on the deformation of the specimen as a whole.

Fracture of cold-worked austenitic nickel–chromium steels following subsequent heating in the temperature range around 700°C K. Skuin (*Technik*, 1960, **15,** Dec., 777–780) It is shown that failure during austenitizing of cold-worked, Nb–Ta stabilized austenitic Cr–Ni steels is due to carbide separation at grain boundaries. Annealing and deformation above 1200°C are reported to destroy stabilization. It is therefore considered that subsequent cold-working and annealing will result in critical carbide separation and fracture.—R.P.

Plastic deformation of cold-drawn prestressing wire S. Ban, K. Okada, and H. Muguruma (*Procs. of Symp. on Prestressed Concrete and Composite Beams. Science Council of Japan*, 1955, Nov., 15–21) Effects of creep and relaxation are examined.

Effect of anisotropy on the plastic deformation of sheet under uniaxial or biaxial stress C. Crussard, D. Lajeunesse, and C. Pomey (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces, et les Essais de Tôles*, 1960, May, pp.30) [In French] A mild steel and three ferritic stainless steels are used in order to study mechanical anisotropy in relation to the rolling angle, the magnetic and crystallographic anisotropy of the steels being determined independently. Tests on asymmetry show that best results are obtained when the minor axis was placed in the direction of rolling. A simplified theory is suggested which, however, does not explain the occurrence of 'ears'.—R.P.

Remarks on the Erichsen drawing test S. Di Bartolo (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloqueeur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.14) [In English] Experiments are described, designed to find the causes of variations in the draw-depth when using the same apparatus, material and method. A theoretical explanation for the scatter of results is put forward. Results obtained by different methods are compared.

Comparison of results obtained by subjecting mild steels to the creep-forming and the Erichsen Deep Drawing Test A. Krüger (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.38) [In German] Results obtained after subjecting mild steel sheet to the cup-forming as well as the Erichsen deep drawing test are compared and found to agree with results obtained by other investigators. Rimming steels, and killed steels manufactured by different processes and in various conditions at heat-treatment are tested; the Erichsen test appears to be more suitable than the deep cupping test.—R.P.

On the correlation among experimental values obtained from various formability tests S. Fukui, K. Yoshida, and K. Abe (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.11) [In English] It is pointed out that the tensile test does not assess the formability of a material. Testing methods which simulate deformations occurring during forming processes are advocated. Attempts are made at correlating results obtained from different formability tests.

Classification and systematization of sheet metal press-forming process K. Yoshida (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.9) [In English] A fundamental, mathematical treatment of press-forming and of the press-forming range is presented. Three principal deformations in press-forming are analysed, i.e. flange deformation, stretching, and bending. Appropriate application of various testing methods are indicated.

An investigation of Swift cupping test correlation and the influence of tool and material surface finish on the test results P. W. Whitton and D. R. Mear (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.22) [In English] Results are presented for the limiting drawing ratio in the Swift cupping test for rimming and stabilized steel, 70–30 brass and Al, the last-nameed imposing the strictest conditions. Punch and die surface quality are stated to be difficult to control. Recommendations are made for defining tool surface roughness.—R.P.

Effect of material properties and of test conditions on the results obtained with the cup drawing test W. Panknin (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.21) [In German] Laws governing deep drawing are discussed and it is shown that the limit of drawability depends on the relation between punch diameter and sheet thickness Therefore results obtained by the Cup Drawing Test cannot be applied directly to tools of other dimensions. It is shown that the properties of the material have only a slight effect on the limit of drawability. In conclusion it is stated that the Cup Drawing Test is of value as a technological test only.—R.P.

Investigations on the Swift Cupping Test J. H. Zaat (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.25) [In English] Theoretical and experimental data are discussed, showing that it is possible to carry out the cupping test independently of sheet thickness and punch diameter, sheet properties being the only variables. Testing equipment and conditions have to satisfy given requirements. An amended definition for the limiting drawing ratio is suggested.—R.P.

Effect of some variables on the Erichsen Test results Jentet (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.18) [In French] Shortcomings of the Erichsen Test are pointed out and variables are investigated. It is suggested that a Euronorm

embodying some of these variables would result in better agreement of results.—B.P.

The assessment of the formability of sheet metal by cupping tests and from the stress-strain characteristics J. F. Wallace (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.14) [In English] The merits of various formability tests are discussed and compared and the theoretical relation between stress, strain, and drawability are elaborated from a theoretical point of view. The performance factors

$$\pi = \frac{\text{UTS}}{\text{yield stress and strain hardening rate}}$$

can be used to compare similar materials.

The hydraulic drawing test for establishing yield curves and relative work-hardening W. Panknin (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.8) [In German] The hydraulic drawing test is discussed and results are used to draw yield curves as well as for the determination of work hardening. The test is compared with the Erichsen cupping test.—B.P.

Anisotropy produced by plastic deformation K. Saito and H. Igaki (*Proc. 1st Japan. Congress on Testing Materials*, 1958, 111–114) This property was studied by experiments consisting of tensile tests of prestrained metal plates under tension; shear tests of the prestrained metals under shear; and shear tests of the prestrained metals under tension, together with tension tests under shear. The tests were on non-ferrous materials.

The effect of manganese on the deep-drawability of steel sheet B. Otta and J. Teindl (*Hutnik*, 1960, **10,** (9), 351–354) The deep-drawability of sheet from six experimental melts containing on the average 0·08%C and only 0·275%Mn was studied. Tests showed the steels to be suitable for multi-stage drawing purposes, though the Erichsen values were somewhat lower than with the usual Mn contents. This need not however affect the adequate workability of the steel.—P.F.

Study of factors influencing ductility of iron–aluminium alloys F. C. Perkins and J. F. Nachman (*AECU–4252*, 1959, July, pp.16; from *US Res. Rep.*, 1960, **33,** Jan. 15, 102) No abstract.

Theory of the metallic state J. A. Catterall (*J. Royal Inst. Chem.*, 1960, **84,** Sept., 311–320) The historical background is outlined leading up to the Fermi-Dirac distribution, Sommerfeld's model, and the zone theory of metals. When an electric field is applied to a metal and an electric current is carried, the electrons are accelerated, being raised to higher energy states; this is only possible when empty levels exist immediately above the Fermi surface for the electrons to occupy. The case of semi-conductors, insulators, and low-temp. conditions are examined. Cohesive forces and the electronic structure of alloys are discussed and recent work relating to 'anomalous Skin Effect' and the De Haas–Van Alphen effect is briefly summarized.—C.V.

Measurement of residual stresses J. Pomey (*Bulletin SFM*, 1958, (27), 1–15, reprint) The reasons for occurrence of residual stresses are summarized. Theoretical and practical aspects of the methods used for measuring residual stresses on the surface and within the metal are discussed and compared. It is pointed out that some of these methods are only useful for research while others lend themselves to routine work.—B.P.

Residual stresses in cold ironed tubes B. M. Botros (*Internat. J. Mech. Sci.*, 1960, **2,** Nov., 195–205) An examination is carried out into the effect of process variables on the pattern and magnitude of the residual stresses in the walls of ironed tubes. Sach's boring method was adopted, a rotary jig being constructed so as to obtain uniform etching of the tubes; NaOH was used for Al and HNO_3 for mild steel. Direct mechanical methods were preferred to electric strain gauges for the measuring of strains. Results showed that high compressive stresses were present in both tube surfaces; these changes to low tensile stresses with max. values towards the outside surface. Radial stresses were always small. Lubrication only slightly affected the surface stresses. It was concluded that internal stresses are reduced to negligible values by ironing to reductions larger than 30% in cross-sectional area; this suggests the possibility that in this process high residual stresses can be prevented by this means. This appears to be the more rational approach rather than attepting to reduce them when they are present.—C.V.

Study on cold drawn steel wire IV (on measurement of residual stress A. Muramatsu and S. Fukui (*Proc. 1st. Japan Congress on Testing Materials*, 1958, 61–65) An examination of the occurrence of residual stresses in cold drawn wire showed that increase in back tension (i.e. drawing force) gave reduced residual stresses. It is concluded that modification of the drawing process to increase [the drawing force will minimize residual stresses.

The theory of the ordering of alloys of the type Fe_3Al. I. V. V. Geichenko and A. A. Smirnov (*Voprosy Fiz. Met. Metallov.*, 1960, (11), 36–41) The question of the ordering of the type Fe_3Al alloy is examined and, in particular, the two temp. of the ordering of this alloy in the framework of the simplest approximation, in which correlation was not taken into account.—A.I.P.

High-temperature heat contents of some binary iron alloys W. B. Kendall and R. Hultgren (*ASM Preprint*, 1960, (191), Oct., pp.8) The heat contents of some binary alloys of iron with Co, Cr, Mn, and Si have been measured over the range 298·15 to 1400°K, using a diphenyl ether drop-type calorimeter with an average experimental precision of about ±0·3%. Deviations from Kopp's law have been tabulated. An anomaly, possibly an antiferromagnetic Néel temp. was discovered at 517°K in $Fe_{0.512}-Mn_{0.488}$ and at 380°K in $Fe_{0.696}Mn_{0.304}$.—S.H.-S.

Heats of formation of iron–manganese alloys W. B. Kendall and R. Hultgren (*ASM Preprint*, 1960, (190), Oct., pp.7) Heats of formation of four γ-phase Fe–Mn alloys containing 22·83, 30·38, 38·80, and 48·80 at.%Mn respectively, have been measured at 298·15°K by acid solution calorimetry. Recent heat content measurements extrapolate the results to 1400°K at which temp. the alloys as well as the pure component metals have fcc crystal structures. The results at 1400°K may be described to ±300 cal/g-atom by the regular solution equation ΔH_f, 1400°K = −4700×(1−x)cal/g-atom, where x is the atomic fraction of Mn in the alloy.—S.H.-S.

Field homogenizing iron plates for the nuclear spin resonance spectrometer K. Antonowicz (*Acad. Polonaise Sci. Bull. Math.*, 1960, **8,** (2), 115–116) [In English] Armco iron plates are used as filters.

Theoretical metallurgy and the demands of ironworks W. Kuczewski (*Preprint*, 1958, 1–9) A preliminary thermodynamic study.

Adsorption and energy of activation in metallurgical processes W. Kuczewski (*Preprint*, 1958, 1–11) It is not possible to obtain quantitative expressions agreeing with actual conditions.

The determination of the coefficient of activity of carbon in alloyed ferrite A. Kalivoda (*Hutn. Listy*, 1960, **15,** (9), 687–689) The relative activities of carbon in four steels, all containing about 0·4%C and about 2% of either Mn, Si, Cr, or Ni were determined by Hillert's method (*Jernkont. Ann.*, 1957, **141,** 67). In the order of the alloying elements given above the activities were 0·80: 1·18: 0·64: 1·00.—P.F.

One method of determining shearing strength in carbon steel M. Nakazaki and H. Oda (*Proc. 1st Japan Congress for Testing Materials*, 1958, 92–94) A method of determining specific shearing force is described, and a relationship between cutting and shearing established.

Proposed procedure for testing shear strength of brazed joints W. Lehrer and H. Schwarzbart (*Weld. J.*, 1960, **39,** Oct., 462s–464s) In this discussion of the paper by F. M. Miller and R. L. Peaslee (*ibid.*, 1958, **37,** April, 144s–150s), an extension of their test procedure is suggested.

Some devices for gripping tensile test pieces K. Takase (*Proc. 1st Japan Congress on Testing Materials*, 1958, 173–176) Two types of self-aligning grips developed by the author are described.

Effects of thickness of tension test specimen for sintered metals on tensile strength and elongation of the materials E. Hayashi (*Proc. 1st Japan Congress on Testing Materials*, 1958, 89–92) The importance of test bar thickness, due to variations in density and structure across the section, are pointed out, and the effect of thickness is examined by analysing the results of tensile tests and obtaining density distribution diagrams in the direction of pressing.

A new tensile flow curve for plane strain K. Takase (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.27) [In English] A new method of obtaining tensile flow curves at very high plane strain is presented. The main features are preparatory compression with two cylinders, followed by a tensile test. Results are discussed in relation to working. A new end portion of the curve is observed.—B.P.

Hot hardness and tensile properties of stainless steel type 304, titanium alloy Ti-150A, and SAE 4140 steel at 300° and 600°F A. K. Wong and G. Gazza (*Techn. Rep. WAL–TR–116/2; PB* 142893, 1959, July, pp.36; from *US Res. Rep.*, 1960, **33,** Jan. 15, 81) Hardness tests were made in a Rockwell and Brinell testers incorporating a resistance-heated furnace, and tensile tests were made at strain rates of 0·1 and 0·5in/sec, specimens being rapidly heated by induction and held at temp. for 1 min (19 refs).

The bond forces and static deformation in crystals of silicon-alloyed iron G. Ya. Kozyrskii and V. K. Kritskaya (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 117–120) It is shown that the presence in the α-iron lattice of 6%Si has no effect on the strength of the bond in iron crystals. The replacement of iron atoms by silicon atoms leads to considerable static deformation of the crystal lattice of the α-solid solution.—A.I.P.

Bendability studies of plate steel quality H. Fujita and H. Ishizuka (*Proc. Japan Congress on Testing Materials*, 1958, 68–70) The relation between bendability and laminated fracture, and the effects of non-metallic inclusions and banded structure on bendability are examined.

Studies on the bending test of forged steels. I. (on minor cracking appearing in the bent surface) H. Shimoda and H. Ishizuka (*Proc. 1st Japan Congress on Testing Materials*, 1958, 71–72) The effect of the size and distribution of inclusions on the initiation of cracks is discussed. **II. (relation between results of the bending test and tensile properties)** H. Shimoda, H. Ishizuka, and H. Fujita (72–75) About 200 specimens of forged crank webs were investigated, containing ~0·40%C. It was found that the values of elongation and reduction in area were closely related to the bend test results. The frequency of appearance of cracking is influenced by elongation and reduction in area. **III. (influence of non-metallic inclusions on bendability)** H. Shimoda and H. Ishizuka (75–77) It is shown that the existence of coarse-grain inclusions is closely related to bendability, and the unsatisfactory bend specimens contain more and larger inclusions than the good samples. **IV. (influence of microstructure on bendability)** H. Shimoda and H. Ishizuka (77–79) It is shown that the presence of Widmanstätten structure had a deleterious effect on bendability. **V. (influence of hydrogen on bendability)** H. Shimoda and S. Onodera (79–82) Test pieces containing sufficient H_2 to cause embrittlement were taken from the core of C steel forgings. Elimination of H_2 by ageing at room temp. for 20 days or at 200°C for a few hours gave improved bend properties. **VI. (Distribution of plastic strain on the bent surface)** H. Shimoda and S. Onodera (82–85) The distribution of plastic strain on the bent surface is measured, and the effect of various factors upon strain distribution is examined and discussed.

Temperature and microstructure dependence of size effects in notched bend tests of some alloy steels S. Yukawa (*ASM Preprint*, 1960,

No.238, 871–881) The 50% fibrous transition temp. was useful for evaluating size effects. The magnitude of the effects varies with microstructure. The size ranges likely to show strength dependencies are discussed.

Impact test on grey iron D. Fortino (*Fond. Ital.*, 1960, **9**, (11), 433–445) The impact test has been the subject of research in countries which are members of the International Iron Testing Committee with a view to establishing whether it can provide an assessment of the capacity of grey iron to resist high dynamic stresses. From work done by the Italian Foundry Testing Committee it is concluded that the determination of impact resistance of grey iron is a useful complement to the tensile strength test and the Brinell hardness test.

Some observations on the Kinzel and drop-weight tests S. A. Agnew, M. D. Mittelman, and R. D. Stout (*Weld. J.*, 1960, **39**, May, 205s–211s) These tests are discussed and compared; the object of the work described was to examine the significance of the tests, and find to what degrees they could be correlated.

Comparison and analysis of notch-toughness tests for welded steel H. H. Johnson and R. D. Stout (*Weld. J.*, 1960, **39**, Nov., 493s–501s) This is a condensation of a WRC bulletin, which was a survey and critical interpretation of the literature on notch-toughness tests (33 refs).

On the breaking behaviour in Charpy impact bending tests M. Tanaka and S. Umekawa (*Proc. 1st Japan Congress on Testing Materials*, 1958, 95–98) A description is given of the design of a simplified apparatus for obtaining load-time curves, consisting of an impact force detector using Rochelle salt crystals. A structural steel containing 0·17%C and 1·08%Mn was tested, and the effects of notch geometry on transition temp. are reported.

Micro-time structure of impact fracture in the Charpy test S. Ono (*Proc. 1st Japan Congress on Testing Materials*, 1958, 98–100) Corrections to be applied for quantitative results from the Charpy test are indicated.

Shock and pressure tests of 9%Ni steel at −196°C C. Vollers (*Metalen*, 1960, **15**, Dec. 15, 415) This is a brief description of shock and pressure tests conducted on a number of 9·5 mm thick cubic and cylindrical tanks filled with compressed nitrogen. The shocks were applied with a 1960 kg weight from varying heights. The applied pressures were of the order of 2 200 lb/in². The tests were conducted under the auspices of the US Steel Corporation at Morrisville, Pa. in the presence of representatives of about 300 governmental and international authorities interested in such projects as the transport of methane and oxygen under pressure. The tests were successful and 9%Ni steel proves to be a suitable material for the transport of compressed gas at low temp.—F.R.H.

Behaviour of riveted and welded crack arrestors R. J. Mosborg (*Ship Structure Comm.*, 1960, *SSSC*–122, pp.114) Development of a welded crack arrestor with tests on various designs are described. Drop weight and explosion bulge tests are correlated with the large-scale tests.

Fatigue: The problem in relation to welded structures R. P. Newman (*Welder*, 1960, **29**, July–Sept., 54–60) The conditions liable to give rise to fatigue failure, the appearance of fatigue, and the principal factors in the problem are reviewed.—C.V.

Fatigue properties of some high-strength steels H. E. Frankel and J. A. Bennett (*NBS Techn. News Bull.*, 1960, **44**, Oct., 174–175) A summary of work for the Frankford Arsenal, available in full elsewhere.

Fatigue strength of notched and cracked mild steel plate specimens under pulsation tension T. Uryu (*Proc. 1st Japan Conference on Testing Materials*, 1958, 1–3) The investigation described showed that an ~0·05–0·06 mm surface layer was associated with the origin of fatigue cracks, and that the fatigue limit for crack initiation and the usual fatigue limit for both plain and deep hyperbolically notched specimens were equal to each other.

Fatigue strength of steel specimens with double notches M. Kawamoto and M. Seki (*Proc. 1st Japan Congress on Testing Materials*, 1958, 3–6) Two types of double notch were used. In the first, the double notches consisted of two circumferential notches, the secondary notch being situated at the root of the primary one. In the second case the system consisted of a groove (primary notch) and a drilled hole (secondary) at the root of the primary. From the three series of tests carried out the notch factors of the double notches were determined.

Fatigue strength of materials under periodical multiple repeated stress in two level M. Kawamoto and T. Nakagawa (*Proc. 1st Japan Congress on Testing Materials*, 1958, 6–10) Equipment is described for determining fatigue strength under varying stress amplitudes and results of tests on a range of C steels, which were also tested at constant stressed amplitude. An equation was formulated to correct for the effects of variable amplitude in fatigue life.

The fatigue strength of welded joints of high tensile strength structural steel I. Konishi, O. Takagi, and K. Shimada (*Proc. 1st Japan Congress on Testing Materials*, 1958, 10–14) Four types of test were carried out on butt welded joints, to determine fatigue strength of the joints, the effects of finishing treatment of the welded parts on fatigue strength, and the influence of different electrodes.

Fatigue strength of mild steel after stress-corrosion or cathodic protection Y. Minami and Y. Fukuda (*Proc. 1st Japan Congress on Testing Materials*, 1958, 20–23) Tests on mild steel plate indicate that stress during corrosion by natural seawater produces a slight decrease in fatigue limit. Limits after five months stress corrosion are about 10% lower than the limit in air. Fatigue strength under cathodic protection is not influenced by applied stress or time of immersion in seawater.

Fatigue strength of carbon steel by etching T. Inukai (*Proc. 1st Japan Congress on Testing Materials*, 1958, 23–25) Etching tests are described on specimens tested in rotary bending and torsion, which differentiate between differences in repeated stress intensity and stress cycles.

Investigations on the relations between the internal friction and the scattering of fatigue strength with internal flaws H. Miki (*Proc. 1st Japan Congress on Testing Materials*, 1958, 26–29) Investigations on the correlation between surface defects, internal friction and the fatigue strength of a shaft steel with surface defects indicated that large defects could induce fatigue fracture, and that the fatigue strength of a specimen with high internal friction was reduced.

Propagation of fatigue cracks in steel T. Isibasi (*Proc. 1st Japan Congress on Testing Materials*, 1958, 37–40) Magnitude of strain amplitude round the top of a crack and velocity of crack propagation are analysed, and two examples are examined—plates with a central transverse slot and rotary bending of steel tubes.

Study of fatigue by rotating bending of different forged and cast constructional steel qualities produced at ARBED Electric Steelworks at Dommeldange P. Wagener (*Rev. Tech. Luxembourg*, 1960, **52**, July–Sept., 133–146) A description of tests and their results is given.

Fatigue of low-carbon steel at elevated temperature (influence of frequency of stress cycles on fatigue at elevated temperature) T. Nishihara, S. Taira, K. Tanaka, and R. Koterazawa (*Proc. 1st Japan Congress on Testing Materials*, 1958, 34–37) Tests were made on a 0·10%C steel at 450 and 300°C with a rotating load type machine, stressing at 170–3 000 cpm. The results are discussed.

The age-hardening power of steel and its fatigue strength T. Sakurai and T. Kawasaki (*Proc. 1st Japan Congress on Testing Materials*, 1958, 30–34) The effect of the following heat-treatments on the notch fatigue strength of a 0·6%C steel is examined: annealing for 40 mih at 50°C above A_3, followed by (1) a low-temp. quench (ice-water quench after reheating for 100 min at 700°C); (2) spheroidizing, and (3) tempering. It is concluded that ageing capacity is a dominating factor in determining fatigue failure in sharp-notched specimens (12 refs).

Thermal stresses in design. XXII. Cumulative fatigue damage S. S. Manson (*Mach. Design*, 1960, **32**, Aug. 18, 160–166) A mathematical discussion; it is pointed out that cumulative damage, in fatigue is complicated by the introduction of non-repetitive loading history and that a generalized procedure cannot be provided which will indicate the mechanism while at the same time being sufficiently simple for practical application. Therefore only two cases are studied: (a) when the initiation of a macro-crack terminates the useful life of the machine, and (b) when the useful life of the part includes an appreciable period during which the crack continues to propagate. With thermal stress problems, the additional complication of mechanical loading is considered since the emergence of a crack not only produces stress concentration but reduction in area, moments of inertia, etc., and as the crack progresses, these effects are accelerated causing the crack propagation to increase. Without external loading, the crack can, to some extent, relieve the internal constraint thus reducing thermal loading; stress concentration is still present but the effect is not so severe as if the load were external. These aspects, again are considered mathematically.—C.V.

An application of the idea of cumulative damage to the results of fatigue tests under progressive load N. Enomoto (*Proc. 1st Japan Congress on Testing Materials*, 1958, 45–48) An equation based on the concept of cumulative damage was applied to experimental results of conventional fatigue tests, and it was found that the equations were applicable in every case.

Cyclic thermal stressing test of steel J. Watanabe (*Proc. 1st Japan Congress on Testing Materials*, 1958, 57–58) Equipment and tests are described for examining the resistance of steels to fire cracking.

Detection of fatigue by ultrasonic attenuation I. Konishi, Y. Sawarsgi, T. Fujii, H. Akashi, and M. Terashi (*Proc. 1st Japan Congress on Testing Materials*, 1958, 41–44) Changes in attenuation factor with the number of repetitions of tensile loading are examined.

Effect of nickel on fatigue strength of structural steels S. Przegalinski, R. Bak, and J. Wojnarowski (*Prace Inst. Hutn.*, 1960, **5**, (12), 219–222) The effect of nickel content on fatigue strength was studied on three Cr–Ni steels heat-treated to an ultimate tensile strength of 105–110 kg/mm². Fatigue strength was determined by symmetrical tension–compression tests and by rotary bending tests on notched and unnotched samples. The results, expressed as the ratios of fatigue strength to tensile strength, do not indicate any clear effect of Ni content on fatigue strength of heat-treated structural steels.

A thermal cracking test for steels and alloys M. Riddihough (*Metallurgia*, 1960, **62**, Aug., 53–57) In the test described, a small cylindrical specimen is heated by an oxy-acetylene flame and water quenched. Results reported include tests on cast iron and steels.

Fatigue of metals under repeated finite strain Y. Takenaka (*Bull. Jap. Soc. Mech. Eng.*, 1960, **3**, Nov., 419–424) [In English] Tests of mild steel and brass specimens under various constant amplitudes of repeated plastic strain carried out to clarify the mechanism of fatigue phenomena, are described and the results summarized.—S.H.-S.

Fatigue strength under multiple repeated stress. (In the case of double change of amplitude in two stress levels) M. Kawamoto, T. Nakagawa, and H. Kohama (*Bull. Japan Soc. Mech. Eng.*, 1960, **3**, Nov., 425–431) [In English] A study, in which fatigue tests were carried out on medium-carbon steel by superposing the higher stress reversals upon the fundamental repeated stress levels, in order to discuss the process of fatigue stressing with investigation of the influence of the cycle ration of the primary stress, the secondary higher stress level, and its reversals on the cumulative cycle ratio to failure. As a result it was found that the more the cycle ratio of the primary stress amplitude and the lower the secondary stress level, the greater the cumulative cycle ratio to failure becomes. Test results have been further interpreted by the use of cycle ratio-damage curves (D–R curves).

Scatter of fatigue life of structural steel and its influence on safety of structure I. Konishi

and M. Shinozuka (*Japan Soc. Civil Eng., Proc. Symp. on Safety of Structures*, 1956, Dec., 37–41) A statistical treatment is presented.

Effect of decarburization and grinding conditions on fatigue strength of 5%Cr–Mo–V sheet steel E. A. Simkovich and E. A. Loria (*ASM Preprint*, 1960, (185), Oct., pp.14) Axial tension–tension fatigue tests on 5%Cr–Mo–V sheet steel were compared with tests on ground sheet of the same gauge and a new method of decarburizing the sheets uniformly to four depths was perfected. The four groups were then heat-treated to 210000 psi tensile strength level without further decarburization. Results show a sharp drop in fatigue strength with small decarburization up to 0·0015in per surface. Specimens ground to 35–40 microin finish and stress relieved produced the highest values. The fatigue test results were correlated with tensile and hardness tests, as well as metallographic analysis, and a method of detecting decarburization based on hardness measurements was evolved.—S.H.-S.

Fatigue testing of vehicle components T. C. F. Stott (*Proc. IME Auto. Div.*, 1958–59, (1), 21–47) Fatigue testing of the more highly stressed parts is discussed.

Criteria for the use of steels in high pressure and high temperature plants. Admissible values for calculation, for safety criteria and for materials A. Feroci (*Met. Ital.*, 1960, **42,** Oct., 661–668) The different formulae for the calculation of tubes and tubing submitted to internal pressure at room and high temp. in absence of or with high radial thermal flux are examined. Considerations on the induced stresses in tubes under restraint and abrupt temp. changes are given. The importance of thermal shock is pointed out and a formula is given for the calculation of the maximum tube heating speed. A list is given of the principal steels used by Dalmine for the manufacture of high temp. tubes.

Effect of organic compounds on metal fatigue (*NBS Tech. Bull.*, 1960, **44,** Aug., 127) Compounds having chain lengths 8, 12, and 18 C-atoms were compared, seven being examined. Those having 12-C gave the greatest increase of fatigue strength. The type of polar group does not appear to be as important as the number of C-atoms.—C.V.

Introduction F. Campus (*Comptes Rendus de Recherches, IRSIA: IWONL*, 1960, Aug., 17–20) In these introductory remarks, the author summarizes work carried out at the Centre de Liège. The research program includes in particular the effect of alternating, continuous, and of short-time stresses on failures **Effects of stresses** F. Campus and K. Gamski (21–52) The effect of short-time surface stresses on the properties of steels is discussed from theoretical and practical points of view. Particular mention is made of the effect of surface skins. **Critical creep stress** F. Campus and K. Gamski (53–57) The authors summarize some creep strength data and go on to state results of creep tests carried out on mild and hard steels. **Relation between permanent deformation and creep in steels at ambient temperature, using a simple tensile test** K. Gamski (58–64) The theoretical and practical aspects of the three stages in creep are discussed with particular emphasis on the deformation produced. **Failure under alternating stress** F. Campus and K. Gamski (65–66) The reasons for, and importance of, fatigue testing are discussed. **Studies on electro-magnetic apparatus used for rupture testing under alternating stress** K. Piotrowski (66–90) The theory of a fatigue testing machine and its action are discussed in great detail from fundamental principles. **Test results** F. Campus and K. Gamski (98–101) Results of fatigue tests on a wire are tabulated and discussed. **Application of the machine** K. Gamski (91–98) The method of operating the fatigue testing machine and registration of results are explained, using a wire of known mechanical properties as an example. **Failure and relaxation in as-rolled, butt-welded steel bars having a tensile strength of about 75 kg/sq.mm** F. Campus, H. Louis, and K. Gamski (102–112) The relaxation failure relationship of as-rolled steel bars of known properties are discussed. Investigations of variables are dealt with. **Summary and conclusions** F. Campus (113–121) Work on relaxation and failure in steels carried out at Liège over 12 years is summarized critically (42 refs).

Recherches du Centre de Louvain R. de Strycker (*Comptes Rendus de Recherches, IRSIA, IWONL*, 1960, Aug., 127–169) After introductory remarks regarding the Institute, the author discusses the layout and work carried out there. Investigations include failures at temp. other than 20°C, the effect of Al on failure of prestressed wire, rapid and long-term testing, the effect of variables on failure, particularly fatigue and creep failure; and stress corrosion testing.—R.P.

Creep in steel J. D. Murray (*Iron Coal Trades Rev.*, 1960, **181,** Nov. 4, 1007–1013) Some technological aspects of the subject are reviewed. It is pointed out that little work has been carried out on the physical and mathematical side of this problem. Relationship between creep resistance and N-content, stress-to-rupture data for boron, and B-free steels, influence of various alloying elements are shown and evidence of lattice strain in an Al 4%Cu alloy, of precipitation of alloy carbides at dislocation lines are illustrated showing the generation of these from boundary effects. General precipitation on dislocation arrays and the generation of dislocations caused by difference in coefficients of expansion are further discussed and it is shown that further precipitation of carbides at these dislocations can occur giving a strengthening effect to the steel. An isometric plot is presented which shows the Mo and V content of steel as a function of time to attain a 0·3% creep strain and the occurrence and positioning of the alloy carbides that form are indicated. The British Standard procedure for the testing is summarized.—C.V.

Creep of low carbon steel under varying temperatures T. Nishihara, S. Taira, K. Tanaka, and M. Ohnami (*Proc. 1st Japan Congress on Testing Materials*, 1958, 48–51) Experiment with 0·14%C steel with varying temp. in the range 425–500°C showed that creep deformation can be predicted approximately from the results of constant temp. tests with certain assumptions.

Creep and rupture properties of carbon steels A. I. Smith, E. A. Jenkinson, and D. J. Armstrong (*IME Advance Copy*, 1960, Sept. 30, pp.22) A further account of work at the NPL, extending tests to 100000 h, is given. The order of merit of the steels tested was the same as for 1000 h. The various types of iron and steel are rated for creep strength. Further directions of the work are indicated.

Influence of composition, structure, and heat treatment on creep characteristics of steels A. Myallonier (*Met. Ital.*, 1960, **42,** Oct., 669–673) The importance of certain metallurgical characteristics on high temp. creep of power plant steels is shown. The characteristics of the main types of steels at varying temp., are considered and the influence of individual elements on high temp. creep are outlined. The effect of the grain edge, the grains themselves, and their size on creep-resistance is analysed. Creep tests carried out in Dalmine's laboratory are described.

A study on the creep rupture test R. Nakagawa and Y. Otoguro (*Tetsu to Hagane*, 1960, **46,** Aug., 982–987) For 18:8 stainless steel, creep rupture time and elongation decreased with increasing quenching temp., but were almost constant above 1100°C. The deviations of creep rupture time were smaller, but of elongation and creep rate larger, in long- than in short-time testing. Deviations were greater with 10 mm dia. than with 6 or 8 mm test pieces.—K.E.J.

Analysis of compressibility in creep by the nonlinear elastic analogue S. A. Patel, B. Venkatraman, and W. P. Vafakos (*Internat. J. Mech. Sci.*, 1960, **2,** Oct., 1–7) The case of a hollow sphere subjected to uniform pressure is analysed and a simple device for including compressibility effects in creep behaviour expressions is given.

Stress analysis in the presence of creep I. Finnie (*Appl. Mech. Rev.*, 1960, **13,** Oct., 705–712) A review of theory (111 refs).

Creep in semi-annular plates P. Ya. Boguslavskii, (**Teploenergetika*, 1958, (2), 56–61) Calculations are presented.

New methods of dealing with creep testing problems W. Siegfried (*Met. Ital.*, 1960, **42,** 1958, Oct., 640–646) After describing the development of methods for long time extrapolation of creep curves the validity of the Larson-Miller method is examined in determining the value of the constant as a function of the stress of temp. and time up to break point. This takes values between 15 and 30 for the same alloy. Finally there is a comparison of the Larson-Miller and Glen methods and new techniques of extrapolation.

Methods at present in use for determining high temperature creep in steels G. Paravicini (*Met. Ital.*, 1960, **42,** Oct., 647–650) A short description of the development of high temp. creep testing and the standards established to determine the creep limits and rupture time. Special reference is made to the standards most often used (DIN and ASTM) with a comparison of the two. The writer proposes that the UNI Standard be brought up to date and finally describes Dalmine's creep test laboratory.

Effect of temperature and stress variations on creep testing applicability of the progressive action method M. Alberghina (*Met. Ital.*, 1960, **42,** Oct., 651–655) By accelerating a test by increasing the influencing parameters, the experimental results of creep tests on heat-resisting alloys AISI 310 carried out by graduated variations in temp. or stress were shown. The results are related to the rupture time and allow application of the calculation of cumulative damage proposed by Miner for fatigue tests. The classical constant temp. test would in this way be replaced by more economical progressive action tests.

Observations on results of short-time creep testing S. Erra (*Met. Ital.*, 1960, **42,** Oct., 656–658) The results of numerous short-time tests (4–5 h) on steel Aq42 plates in the temp. range 370–450°C are analysed. A comparison is made between the data published in American journals for medium duration tests carried out on the same type of steel and the differences resulting from the comparison are discussed.

Proposed methods for extrapolation of creep to rupture tests P. Brozzo (*Met. Ital.*, 1960, **42,** Oct., 659–660) The time temp. parameters proposed for the correlation of creep test results, i.e. the Larson-Miller, Dorn, and Mason Haferd parameters are considered. Special reference is made to the constant which appears in the Larson-Miller parameter which according to these authors should have the character of a general constant. Research is being carried out on this subject by the writer.

Creep buckling of composite members J. M. Alexander and G. A. Webster (*J. Mech. Eng. Sci.*, 1960, **2,** Dec., 342–348) A simplified theory (*idem*, 1959, **1,** 211) is extended and generalized to cover the case of thermal creep buckling of prismatic two-member components such as reactor fuel elements, all phases of creep and elastic strains being taken into consideration. Typical curves are presented based on data for an Al-alloy; these show the contribution to buckling deflection which is likely to occur from primary creep for a single rod.

Mechanical failure of steels G. C. Davitz (*Engineer Foundryman*, 1959, **25,** Dec., 41–47) A review with a classification. Some 17 examples are discussed.—C.V.

Notes on an examination of unforeseen breaks in constructional steel girders E. Maccaferri (*Constr. Met.*, 1960, **12,** Nov.–Dec., 299–304) The writer discusses the problem of identifying the causes of sudden breakage of constructional steel sections during erection operations but not under work loads. Information is also given on the methods used in analysing the materials by means of experiments carried out by the materials testing department of a large German constructional engineering firm.

Speed of loading and time of load application in Rockwell hardness testing K. Kuroki and S. Komuro (*Proc. 1st Japan Congress on Testing Materials*, 1958, 147–151) True indentation curves were found by the electric inductance type displacement gauge, effects of loading speed and hardness on the curves were examined, and the dependence of hardness values on these factors analysed.

On effects of some angles of inclination on

the Shore hardness number S. Machida (*Proc. 1st Japan Congress on Testing Materials*, 1958, 151–155) The effects of inclination of the measuring tube, specimen, and tester on the results of Shore hardness tests were examined.

The influence of austenitic grain size, heterogeneity and inhomogeneity on the hardenability of steels U. Wyss (*Schweizer Arch.*, 1960, **26,** Sept., 339–346) The importance of the Jominy test for assessing the hardenability of steels is discussed, and the relationship between the ASTM grain size scale and the Shyder-Graff method indicated. A distinction is drawn between austenitic inhomogeneity due to differences of concentration within a structurally homogeneous austenite, and the heterogeneity of an austenite containing particles of a different phase. The influence of the heterogeneous austenite structure on the hardenability and transformation behaviour of various steels is discussed (19 refs).

The study of strain ageing in rimming steel using the Swift cupping press and the influence of punch shape on the results D. K. C. Ullmann and V. M. Thomas (*International Deep Drawing Research Group. Société Française de Métallurgie. Colloque sur la Mise en Forme des Tôles Minces et les Essais de Tôles*, 1960, May, pp.15) [In English] Results of experiments are discussed which show that the Swift cupping test does not discriminate sufficiently between the change in mechanical properties before and after ageing to warrant its use as a tool for studying strain ageing. Modifications made to the punch shape are discussed but fail to follow changes in yield point and other properties associated with strain ageing. These conclusions apply to rimming steel strain aged in the cold reduced, annealed, and temper-rolled condition.—R.P.

The criterion for hot-shortness in alloys Ya. A. Smolyanitskii (*Izvest. VUZ Chern. Met.*, 1960, (2), 124–126) A theoretical consideration of the probability of hot cracking of castings during cooling based on a definition of the mechanical properties of the cast metal, by means of the limiting speed of the elastico-plastic deformation which the alloy can withstand without failure at temp. near the solidus

A new testing method to obtain critical stress and limiting temperature for the propagation of brittle fracture (double tension test) M. Yoshiki and T. Kanazawa (*Proc' Ist Japan Congress on Testing Materials*, 1958, 66–68) Static instead of shock loading is used, and in the equipment described the specimen is in two parts; brittle fracture is initiated in the first part and propagated in the second. Values of critical stress and limiting temp. for brittle crack propagation are determined.

Investigation of the effect of hydrogen embrittlement and its relief in phosphate coated AISI 4340 and 1095 steels P. H. Austin, S. V. Chek, and W. Lurie (*NWPW–T–20–59; NAVORD rep.*6509; *PB* 143424, 1959, Aug., pp.33; from *US Res. Rep.*, 1960, **33,** Jan. 15, 81–82) The effect of H_2 embrittlement was investigated at various hardness levels by the use of sustained load (ring) tests made at 80% of the uncoated notch-breaking strength of the steels for corresponding hardness.

Brittle fracture in welded structures C. E. Mavrocordatos (*Engineer Foundryman*, 1960, **26,** Oct., 30–39) The mechanical and metallurgical factors affecting the ductility of mild steel are very briefly reviewed. The effect on flow stress and fracture stress of temp. and rate of loading is shown in a three-dimensional model. The effect of the metallurgical changes induced by welding are discussed and relevant examples of service failures are shown.

International enquiry into brittle fractures International Welding Institute (*Soud. Techn. Connexes*, 1960, **14,** Nov.–Dec., 432–435) A short survey is given of the conditions under which international research on brittle fracture was carried out. The variables studied are quoted and guidance given regarding presentation of results.—R.P.

Brittle fracture of pressure vessels and information required to prevent it by appropriate means A. A. Wells (*Soud. Techn. Connexes*, 1960, **14,** Nov.–Dec., 449–454; also *Rivista Ital. Soldatura*, 1960, **12,** Sept.–Oct., 222–227) Some reasons for failures of pressure vessels are discussed. The influence of transition temp. on the initiation and propagation of brittle fracture is referred to in particular. It is suggested that attention be paid to design and construction (26 refs).—R.P.

Influence of hot-rolling conditions on brittle fracture in steel plate F. de Kazinczy and W. A. Backofen (*ASM Preprint*, 1960, (182), Oct., pp.19) Steel plates processed by conventional controlled (low finishing temp.) rolling practice were studied to find reasons for superior notch toughness in the controlled-rolled product. The lower transition temp. (Charpy V-notch 15 ft/lb) in plates investigated derived largely from a smaller ferrite grain size. Part of the improvement results from a micro-fissuring in the plane of the plate at the notch root, with the effect that stress triaxiality is relieved and transition temp. depressed. Flaws responsible for the fissures were probably inclusions in a fibre structure too fine for observation with normal metallographic techniques. The microfissuring criteria are presented and discussed.—S.H.-S.

Embrittlement of steel in contact with liquid phase. I. Embrittlement of mild steel in contact with molten copper–lead alloys M. Nakajima (*Tetsu to Hagane*, 1960, **46,** Aug., 967–972) As the amount of Cu in the liquid increased, mild steels in contact became more brittle. The contact angle between γ–Fe and the liquid fell, down to 20°C. Fracture stresses estimated from contact angles and obtained from tensile tests are compared (10 refs).—K.E.J.

Circular-patch test for evaluating armour crack susceptibility L. E. Poteat and R. W. Jones (*Weld. J.*, 1960, **39,** Aug., 357s–364s) Work was done on this test in order to find a satisfactory procedure. A method was evolved that gave consistent results for the heats examined, when compared with their known fabrication histories.

An appraisal of structural steels by thermodynamics W. Kuntze (*Stahl Eisen*, 1961, **81,** Jan. 19, 123–125) The author discusses the possibility of predicting the tendency of a steel to brittle fracture by 'thermodynamic' methods meaning by this the notched-bar tensile-notch impact tensile test. The merits of this test are discussed.—T.G.

The Schiefer abrasion machine P. B. G. Upton and R. H. Bromley (*Wear*, 1960, **3,** Sept.–Oct., 388–393) The design is discussed. The action is considered and some improvements are suggested which would permit a more uniform friction with a wider variety of abradants.—C.V.

Effects of lubricant composition on sliding friction of steel on steel F. G. Rounds (*Gen. Motors Eng. J.*, 1960, **7,** July, Aug., Sept., 36–41) Most synthetic fluids had friction characteristics similar to straight mineral oil. Kel–F and an F-alkyl camphorate ester gave higher kinetic friction values than those for naphthenic base oils. Paraffinic base oils with glycerol and ethylene glycol gave lower values; these are the most effective. Fatty acids and related compounds were the most beneficial in lowering static friction. To obtain lower values at velocities >100 ft/min, reactive-Cl and S-compounds were required.—C.V.

Frictional properties of carbides and borides at high temperatures B. L. Mordike (*Wear*, 1960, **3,** Sept.–Oct., 374–387) Measurements have been made over a temp. range to 2000°. The coefficients of friction of carbides and borides on borides first decreases with increasing temp.; then at a definite and reproducible point (800–1400°) it increased rapidly. It was considered that intercrystalline bonding accounted for the initial decrease and that at the point indicated, a change occurred in increased adhesion between the sliders and crystallites; this resulted in increased friction. When sliding on graphite, the friction continued to decrease. In those cases where the friction increases, there is evidence of plastic flow and sintering, this latter being the most important factor. Where it does not occur, as with B_4C and graphite, there is no sharp increase in the coefficient of friction.—C.V.

Testing of the wear resistance of metallic blast shot E. Bickel (*Stahl Eisen*, 1960, **80,** Dec. 22, 1944–1948) The conditions are discussed for a standardization of the wear testing of blast shot by centrifugal forces. A method was designed for replacing the sieve analysis by a dust removal, or in other words by testing the weight losses of the shot. The advantages offered by this new method are stressed.—T.G.

Effect of testing conditions on the result of wear tests of blast shot H. Krautmacher (*Stahl Eisen*, 1960, **80,** Dec. 22, 1949–1952) In the testing of shot it was found that the shape of the baffles and the wear of the throwing blades may affect the life of shot by up to 30%. The reasons for the changes are discussed and suggestions made for improvement in the service life of the shot.—T.G.

On the abrasion test of carbon steel in contact with soil (wear of track group in tractor 1) A. Yagi (*Proc. 1st Japan Congress on Testing Materials*, 1958, 85–89) Abrasion tests carried out with the Amsler-type abrasion testing machine under conditions resembling those found in practice are described.

Detection of cracks and fissures by ultraviolet fluorescence F. Gobin (*Chim. et Ind.*, 1960, **84,** Oct., 532–550) The author has improved the sweating process by using fluorescent impregnating liquids and a mercury vapour lamp as the light source. The most suitable impregnating liquid found is a mixture of Yellowish Green M.C. dissolved in petroleum and Rhodamin B dissolved in alcohol, both in equal amounts. The best absorbent powders for reinforcing are levigated alumina and very fine grained talc. This method of detection achieves interesting results especially when operating on castings with a rough surface. It does not reveal underskin defects but is suitable for all materials, magnetic or not, conducting or insulating.

The photo-densitometer for the structural analysis of metals and its application to cast iron T. Kusakawa and S. Iijima (*Waseda Univ., Rep. Casting Res. Lab.*, 1959, Dec., 27–35) This paper gives the design of the photo-densitometer and its application to cast iron. It can be used successfully in the analysis of structure of cast iron in the following manner: to rate relative areas of graphite and ferrite in cast iron. It is found from a new point of view that the amount of graphite and ferrite are closely correlated with the chemical composition and the mechanical properties.—C.F.C.

Efficient set-up speeds magnetic inspection R. Bower (*Foundry*, 1960, **88,** Oct., 183–186) The use of the Magnaflux CRV–1637 power pack unit with an output of 7000 amps for controlling magnetization in the plant of Pacific Valves Inc., Long Beach, Calif., its initial usage and incorporation into a standard roller conveyor, with resultant economies, including 83% reduction in operation time, is described.—S.H.-S.

Crack-detection is applied on a production basis Fel-Electric Ltd (*Metalw. Prod.*, 1960, **104,** Sept. 21, 83–84) A unit using a magnetizing technique, whereby an eight-spoked indexing work carrier automatically brings components to a testing station, where they are simultaneously magnetized by ac current flow for longitudinal flaws and dc flux for transverse flaws, with fine ink-spray detection, is briefly described.—S.H.-S.

The magnetometric investigation of the diffusion of cementite during the electric heating of type U8 steel Yu. A. Kocherzhinskii and V. G. Permyakov (*Voprosy. Fiz. Met. Metallov.* 1957, (8), 44–50) A method is proposed for investigating cementite diffusion according to the change in magnetic effect. Data on the diffusion rate of cementite during electric heating agree well with those obtained by the electric-resistance method.—A.I.P.

Obtaining standards for magnetic determination of martensite (α-phase) in 18/8 steel T. Malkiewicz, J. Karp, and A. Mazur (*Hutnik*, 1960, **27,** (10), 372–376) As introduction the authors consider present methods of detecting austenite in 18/8 steel and go on to consider standards for magnetic examination containing 100% martensite. Original work is done with X-rays and the following conclusion is reached: with sufficient deformation and correct temp. a standard containing 100% ferromagnetic base can be obtained directly with a max. error of ±3%. With Ni above about 9% lower temp. of deformation and/or larger stresses should be used.

Internal ferromagnetic resonance and magnetostatic modes in nickel–iron alloys J. C. Anderson (*Prod. Phys. Soc.*, 1960, **76**, Aug., 273–281) Some correlation has been found with the known variation of anisotropy energy with composition. With Ni, the total anisotropy has been found to be a minimum ~65% and some indication of long range ordering in the region $FeNi_3$ has been noted. The results obtained provide a degree of support for the existence of magnetostatic spin-wave resonance modes when propagation and exchange effects can be neglected (15 refs).—C.V.

Magnetothermal effects in silicon–iron alloys N. H. Saunders and R. S. Tebble (*Proc. Phys. Soc.*, 1960, **76**, Aug., 282–294) This research is concerned with the measurement and interpretation of reversible magnetothermal effects in Si–Fe alloys of which two polycrystalline types were examined, 4% and 0·288%. Within the limits imposed by lack of knowledge of the basic magnetic parameters of the materials b'' in each specimen tends to the value $b=(T/K_1)(\delta K_1/\delta T)$ as H increases. The effect of the 'spike' domains is discussed; this model however does not account by itself for the decrease in the numerical value of b'' as H decreases. Other processes such as the usual rotational mechanism (also specified by b), probably also occur, but the theory is insufficiently developed to enable a separation to be made. Fair agreement is found between the thermal measurements for the 4% treated and untreated specimens. Results obtained on the latter by Bates and Marshall are discussed and it would appear that the a values then available were incorrect. With revised estimates of a, most, but not all of the irregularities are removed.—C.V.

Observations of the magnetization reversal process in thin films of nickel–iron, using the Kerr magneto-optic effect M. Prutton (*Brit. J. App. Phys.*, 1960, **11**, Aug., 335–338) Observations of the magnetization reversal process in uniaxial thin films of Ni–Fe about 1500 Å thick are reported and the technique is described. The results suggest that this phenomenon in a film oriented with its easy axis at an oblique angle to the applied field occurs in three stages: (i) coherent rotation until the angle is reached where a discontinuous jump in the orientation of the magnetization is expected to commence; (ii) domain nucleation and growth from this angle to that where the jump should finish; (iii) a coherent rotation until the magnetization lies along the field. The way in which some of the actual films deviate from this model is discussed.—C.V.

Some problems on studies of thermal evaluation of magnet wire K. Mase and M. Koga (*Wire Wire Prod.*, 1960, **35**, Sept., 1141–1146, 1192) Considerations bearing on life expectancy, such as heat resistance, varnish treatments, and other insulating materials, with a method for cutting short the life test are presented and discussed.—S.H.-S.

An investigation of 50% nickel–iron alloy for a square-loop core T. Tsundoo and M. Murase (*Suiyokwai-Shi*, 1958, **13**, Sept., 472–477) 50%Ni–Fe alloys with rectangular hysteresis loops were melted both in vacuum and normal atmospheres in industrial furnaces. Using vacuum melting, the oxygen content of the alloy decreases to $\frac{1}{4}$ of that of normal atmospheric melted materials, also the magnetic properties and the recrystallization behaviour are improved. By X-ray determination, it is clear that in the vacuum melted alloy the recrystallization cube texture can be readily obtained by a suitable anneal within a rather wide temp. range, and it is difficult to bring about secondary recrystallization when heated to the higher temp. That is, the oxide inclusions, if present in excess, may reduce the magnetic properties and also tend to disturb the recrystallization process and grain orientation.—R.S.F.C.

Time decrease of permeability of substitutional ferromagnetic alloys C. Kuroda (*J. Phys. Soc. Jap.*, 1960, **15**, Oct., 1898) [In English].

On the new Elinvar-type alloy 'Moelinvar' in the ternary system of cobalt, iron and molybdenum H. Masumoto, H. Saito, Y. Sugai, and T. Kono (*Nippon Kinzoku*, 1960, **24**, Jan., 44–46) Data are given for the coeff. of expansion and the rigidity modulus and its temp. coeff. for alloys containing 45–80%Co, <25%Mo, bal. Fe. In certain composition ranges, these show Elinvar-type properties.—K.E.J.

Change in the coercive force in cyclic heat treatment above and below the Curie point, and its connection with dislocation structure I. Ya. Dekhtyar and E. G. Madatova (*Ukrain. Fiz. Zhur.*, 1958, **3**, (5), 659–663) The material examined was an Fe– at 8·%Al alloy, with a Curie point of ~710°C. Multiple quenching at 600 and 800°C respectively showed a gradual increase in coercive force in the former case, while the coercive force remained practically constant in the latter case (10 refs).

Initial magnetic permeability in the system $Mn_xFe_{3-x}O_{4+y}$ A. Braginski (*Acad. Polonaise Sci. Bull. Techn.*, 1960, **8**, (9), 525–532) A very good agreement is obtained with results based on the Kersten theory and the measured permeability values. It is concluded that the reversible magnetization process in this system is probably due to changes in convexity of 71° and 109° of the Bloch walls, with the dominating magnetocrystalline anisotropic energy as against the magnetic surface energy of these walls. The new model, proposed by Kersten has demonstrated its usefulness in the present case; previous suggested models were unsatisfactory.—C.V.

A study of the influence of plastic deformation on the electrical properties of alloys of the Fe–Al system I. Ya. Dekhtyar, S. G. Litovchenko, and R. G. Fedchenko (*Voprosy Fiz. Met. Metallov.*, 1960, (11), 121–128) The relationship was obtained between the change in electrical resistance and the degree of plastic deformation for pure iron and for alloys of the Fe–Al system containing 0·13, 0·28, 0·42, 0·62, 0·69, and 1·08%Al (11 refs).—A.I.P.

Viscosity and electrical resistance of liquid alloys of the Fe–C system B. M. Turovskii and A. P. Lyubimov (*Izvest. VUZ Chern. Met.*, 1960, (2), 15–20) Measurements of viscosity and of the electrical resistance of liquid alloys of this system are tabulated. The findings show, *inter alia*, that the viscosity remains practically unchanged with an increase in the carbon concentration up to 3% between 1550 and 1600°. This may be explained by the mutual compensation of certain factors which act on the viscous flow. Only in hypereutectic alloys does the effect of carbon begin to exert an appreciable effect on the viscosity, which is explained by the increasing number of microparticles of carbon.

The viscosity and electrical resistance of liquid alloys of the iron–silicon system B. M. Turovskii and A. P. Lyubimov (*Izvest. VUZ Chern. Met.*, 1960, (1), 24–27) Measurements of the viscosity and electrical resistance of alloys of this system have been carried out including also those of pure Si. Two series of alloys were prepared, one of pure iron with Si additions in percentages by weight up to pure silicon, and the other series with additions of silicon in atomic percentages. The tabulated results agree with the maximum values for the heat of solution of these alloys in the region of 40–70 atom %Si and with the deviations from Raoult's law. This supports the theory that there is a relation between the form of the viscosity isotherms and the electrical resistance of these liquid alloys.

The electrical conductivity at high temperatures of the solid solutions of silicon in iron V. I. Igishev and P. V. Gel'd (*Izvest. VUZ Chern. Met.*, 1960, (2), 90–94) The article reports on an investigation of the electrical conductivity of alloys of the Fe–Si system, containing up to 18%Si in the temp. range between 20 and 1000°. The findings are recorded graphically. In pure and technically pure alloys the graphs of the electrical resistance are nearly similar and are characterized by a uniform increase of ρ with temp. (up to the Curie points) where a break takes place conditioned by the destruction of the domain of spontaneous magnetization. Below the Curie points the electrical resistance of these alloys increases more or less uniformly for an increase of the Si content up to 12%.

Non-destructive testing. Ultrasonic methods. Part 1 W. E. Schall (*Instr. Practice*, 1960, **14**, Oct., 1078–1087) Methods are outlined and apparatus is reviewed with a theoretical introduction and simplified mathematical treatment.

Attenuation of ultrasonic waves in steel plate by a segregation band S. Tsukamoto, K. Kanazawa, and M. Motoyama (*Suiyokwai-Shi*, 1958, **13**, Sept., 483–487) The authors studied the origins of the attenuation of ultrasonic waves by segregation bands in steel plates. They investigated the attenuation in samples containing a large quantity of P (0·1% max.) or S (0·04% max.) and many steel plates include segregation bands. It was found that both of the attenuatons, one in the band which includes a large quantity of P (0·1% max.) and the other due to the reflection at the boundary of the band, are small. The attenuation of ultrasonic waves by segregation bands depends on the presence of many sulphides or silicates in these bands.—R.S.F.C.

Ultrasonic-detected flaws and mechanical properties of steel forgings K. Yamaguchi and T. Hayashi (*Proc. 1st Japan Congress on Testing Materials*, 1958, 103–107) The extent and nature of defects detected by ultrasonic inspection are analysed, and their effect on mechanical properties, in particular fatigue strength, are examined.

Wire testing by ultrasonics W. Lehfeldt (*Wire Wire Prod.*, 1960, **35**, Sept., 1131–1133, 1178–1179); from *Draht-Welt*, 1960, March) This describes a new technique that makes possible the detection of internal flaws in wire. The complete testing equipment with Echoscope and Echomat is described and illustrated and its functions and operation are discussed.

Study of mechanical and magnetic characteristics of ferromagnetic materials by ultrasonic technique W. J. Bratina and D. Mills (*Canad. Min. Met. Bull.*, 1960, **53**, Oct., 788–791) Armco iron, SAE 1020, and 4340 steels, and AISI 420 stainless were examined by a pulsed ultrasonic technique. The attenuation is analysed into two components either of which may be dominant depending upon the conditions. Studies of fatigue and brittle transformations could be made.

Investigation of the characteristic absorption of X-rays in binary alloys of iron with nickel, cobalt and chromium L. G. Nikolaeva and S. M. Karalnik (*Ukrain. Fiz. Zhur.*, 1959, **4**, (2), 260–267) [In Ukrainian] An account is given of an X-ray investigation of the change in the position of the K-edge of absorption of Fe, Ni, Cr, and Co in the alloy systems Fe–Ni, Fe–Cr, and Fe–Co, and the results are interpreted in terms of a possible relationship between Kunzel's rules for X-ray spectra and Wägerd's rules for change in the lattice parameter during alloying (10 refs).

X-Ray measurements of residual stresses on various carbon steel specimens deformed by tension S. Karashima, H. Fujiwara, and K. Kojima (*1st Japan Congress on Testing Materials*, 1958, 59–61) The results obtained are reported and analysed, and the deformation mechanisms discussed.

Applications of X-ray diffraction to quantitative analysis M. Robert, G. Pomey, and M. Angeli (*Chim. Anal.*, 1960, **42**, Nov., 533–542) As the intensity of the X-rays diffracted by a crystallized body can be related to its content in any mixture a method of quantitative analysis can be established by measuring the diffracted rays. This principle is here applied to the determination of iron oxides. The method used requires the use of an internal standard and the construction of calibration curves. The writers describe the method and cite several examples.

Identification *in situ* of cementite by X-ray diffraction P. Gendrel and L. Jacqué (*Comptes Rend.*, 1960, **251**, Nov. 14, 2166–2168) About 30 diffraction spectrum lines were identified on a 1%C steel without isolating the carbide.

A study of residual stresses in hardened steel induced by phase transformations D. F. Koistinen and R. E. Marburger (*Gen. Motors Eng. J.*, 1960, **7**, July–Aug.–Sept., 13–17) X-Ray diffraction measurements have been used. Investigations on carburized steels show the close relationship between phase composition and residual stress distributions through the carburized case and the residual compressive stresses are caused by the expansion which accompanies the austenitic–martensite

transformation in the case after the core has been formed. The residual stresses in ground surfaces show that compressive stresses are developed at the surface and tensile stresses immediately below. The cause of the surface compression has been ascribed to mechanical deformation during grinding while the tensile stresses are due to a shrinkage of the layers immediately below the surface as they are tempered. The base material remains unaffected. The distribution of microstrains are expressed mathematically and the form of the expression suggests two distinct modes operating during the austenite–martensite transformation.—C.V.

Temperature characteristics of the iron–vanadium alloys V. I. Iveronova, O. N. Kassandrova, and E. G. Rozantseva (*Izvest. VUZ Chern. Met.*, 1960, (1), 133–135) An account is here given of X-ray measurements of the temp. characteristics determined from the intensity ratio of the X-ray lines, taken at different temp., for alloys rich in V (6–28%). It was found that the X-ray temp. characteristics of the alloys are considerably higher than for pure iron. For example for Armco iron this was found to be ~400° while for the different alloys it varied between 475 and 540° according to the composition, i.e. from 6 to about 29%V.

Gamma ray inspection of steel castings J. Taylor (*Engineer Foundryman*, 1960, **26**, Sept., 21–23) The radiological equipment and the labyrinth type of building used for personnel protection at the David Brown Foundries Division at Penistone, Yorks, are described.

Resonant scattering of the 14 keV iron–57 γ-ray, and its interference with Rayleigh scattering P. J. Black and P. B. Moon (*Nature*, 1960, **188**, Nov. 5, 481–482) A letter.

Potential scattering of neutrons for Fe, Co, Ni, Cu, Zn, &c W. Ratynski, J. Turkiewicz, and P. Zupranski *Acad. Polonaise Sci. Bull. Math.*, 1960, **8**, (2), 117–118) [In English] Cross-sections and effective nuclear radii are calculated. For Fe these are 8·7 ± 0·3 and 8·5 ± 0·1.

Variation of thermal conductivity with temperature (*Mat. Design Eng.*, 1960, **52**, (3), Sept., 177) Curves are given for steels and some cermets, as well as for non-ferrous materials.—C.V.

Analysis of solar furnace performance in mechanical testing at extremely high temperatures G. S. Leon and M. E. Shank (*Trans. ASME, J. Eng., Power*, 1960, **82A**, Oct., 325–332) Tests on fluxes and tensile testing at high temp. are discussed. Furnace characteristics for producing high temp. for fairly large specimens are considered. High aperture and special shape furnaces would be useful.

The plasticity of steels at high temperatures M. P. Braun, O. S. Kostyrko, N. T. Litenko, A. N. Sokol, B. B. Vinokur, and E. I. Mirovskii (*Izvest. VUZ Chern. Met.*, 1960, (2), 57–61) An increase in the temp. of melting 45 steel, from 1240 to 1270°, of Kh55 steel from 1220 to 1250°, and of 5KhNT steel from 1180 to 1210° causes no reduction in plasticity, before deformation, and has no harmful effect on their behaviour when worked with pressure. At high temp. (1100–1200°) their plasticity increases in the order in which they have been listed above.

Relation between the self-diffusion coefficient of iron in steel and temperature P. L. Gruzin, A. P. Gulyaev, V. G. Martinson, and Yu. A. Polikarnov (*Izvest. VUZ Chern. Met.*, 1960, (1), 167–170) After applying electrolytically a layer of radioactive iron, one group of specimens were subjected to a diffusion anneal after first being treated to stimulate grain growth (alternative B) and the remainder were left without such treatment (alternative A). Specimens consisted of U7 steel (0·73%C) because with a carbon content near to the eutectic the self-diffusion of iron can be observed in the γ-state at very low temp. The results have been tabulated. The high diffusion rate of iron in small grains which has been established, may be caused by the fact that self-diffusion occurs preferentially along the boundaries and there fore small grains would promote an increased rate of diffusion. Alternatively at low temp. (in specimens B) there still persists the effect of the phase transformation with the formation of austenite which is stronger the lower the temp.

Effect of compression on self-diffusion of iron in alloys with small amounts of aluminium S. D. Gertsriken and M. P. Pryanishnikov (*Ukrain. Fiz. Zhur.*, 1958, **3**, (5), 651–658) Specimens in argon up to 150 kg/cm² with 0·27 and 0·39%Al at 1100–1250° showed decreased activating energy and increased self-diffusion rate.

The diffusion and interatomic reaction in alloys based on transition elements in the iron group I. Ya. Dekhtyar (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 77–90) A definite link exists between the parameters which characterize the mobility of atoms in metals and the factors which, to a known degree, describe the situation of atoms in the crystal. Both the composition of the atom and their mobility are determined by the interatomic reaction and by the movement of electrons in the metals (16 refs).—A.I.P.

Hydrogen diffusion in mild steels P. K. Foster (*Nature*, 1960, **188**, Oct. 29, 399–400) A letter. Evidence against the applicability of Fick's laws is presented and the actual curves obtained are discussed.

On the mechanism of occlusion of hydrogen by cold-worked hypoeutectoid iron–carbon alloys J. E. Werner and H. M. Davis (*ASM Preprint*, 1960, No.237, 853–869) Both endo- and exothermic mechanisms of occlusion were identified in the equilibration of H_2 with cold-worked Fe–C alloys at 250–400°C. Both are fully reversible. Strained ferrite occludes 3–4 times as much as annealed ferrite. The exothermic mechanism is regarded as chemisorption on internal surfaces created during deformation.

The formation of flakes due to hydrogen under static loads V. O. Valanti (*Rivista Ital. Saldatura*, 1960, **12**, Nov.–Dec., 269–281) Tests carried out by the Finnish delegation of the IIW on the formation of hydrogen flakes under static loads are described. Basic, acid, and rutile type electrodes were used and tensile tests were made during which by ultrasonic means the moment of formation of flakes was revealed. The tests showed that the formation of flakes only happens when stresses exceeded the yield point and approach the breaking point.

Solubility of nitrogen in liquid iron and iron alloys. II. Effect of nickel, cobalt, molybdenum, chromium and vanadium on the solubility in liquid iron S. Maekawa and Y. Nakagawa (*Tetsu to Hagane*, 1960, **46**, Aug., 972–976) The solubility of N_2 in liquid Fe is decreased with increase in Ni and Co, but increased with increase in Mo, Cr, and V. Equations give the effects of the elements on the activity coeff. of N_2.—K.E.J.

The behaviour of inert gases in metals C. E. Ells (*Canad. Min. Met. Bull.*, 1960, **53**, Nov., 885–892) Formation by irradiation is described. Boron stainless steel is included.

The effect of phosphorus on the elevated-temperature strength and weldability of some low-carbon austenitic stainless steels G. R. Rundell and R. J. Raudebaugh (*ASM Preprint*, 1960, (194), Oct., pp.18) The effect of up to 0·62%P on the elevated temp. strength of three types of low-carbon (0·03 max.) austenitic stainless steel has been evaluated by stress-rupture tests at 1200°F, and by short-time tensile tests at 75, 900, 1200, and 1500°F. The addition of P results in marked strengthening of Types 304, 310, and 316 stainless steel, particularly at 1200°F. Weldability tests made on types 304 and 316 stainless steel containing 0·30%P indicate that such steels can be welded successfully if the carbon content is below 0·03% and if the Ni content is on the low side of the composition range for these steels. These weldability tests correlate well with hot ductility test results.—S.H.-S.

On the hardenability effect of boron in steel R. A. Grange and J. B. Mitchell (*ASM Preprint*, 1960, (188), Oct., pp.29) Factors determining quantity and rate of precipitation of the boron constituent were investigated in a series of type 86B00 steels containing 0·2, 0·5, and 0·8%C. Loss in hardenability when boron steels are austenitized at too high a temp. is shown to be directly related to the kinetics of precipitation of the boron constituent. The marked decrease in the hardenability effect of boron as the carbon content of the steel decreases is attributed to the observation that, for any given amount of boron dissolved in austenite, boron constituent precipitates faster and in greater quantity the greater the carbon content of the steel. Boron has a potent hardenability effect in minute percentages, possibly because it concentrates at preferred nucleation sites as austenite is cooled to the transformation temp. range.—S.H.-S.

The effect of small additions of vanadium on the properties of structural steels M. I. Gol'dshtein and S. G. Guterman (*Stal'*, 1960, (12), 1130–1134) Amounts of even 0·01–0·03%V gave considerable increases in strength possibly arising from dispersion hardening. Ductility and impact strength are reduced and to develop the improved strength special heat-treatment is required. It should be found out whether the customary 0·1–0·2%V is needed.

Study on the copper-bearing low-carbon steels. I. Effect of alloying elements on precipitation-hardening characteristics of copper-bearing low-carbon steels M. Okamoto, R. Tanaka, and R. Ito (*Tetsu to Hagane*, 1960, **46**, Aug., 961–967) With solution-treated steels, hardening by Cu pptn. was only found with Mo addition. With furnace-cooled and quenched steels, Mn, Cr, and Mo retarded hardening by C pptn. With oil-quenched steels, Mo promoted high hardness caused by Cu pptn. Ni reduced red-shortening (11 refs).—K.E.J.

Effect of aluminium on density of electrical steels R. J. Bendure (*Metallurgia*, 1960, **62**, Aug., 58–60) Examination of the effect of Al, Si, Cu, and Mn on the density of these steels showed that only Si and Al have an appreciable effect. A formula is given showing the effect of these elements.

Effect of arsenic and tin on the solubility of graphite in molten iron H. Sawamura, T. Mori, A. Kobayashi, and T. Miyashita (*Suiyokwai-Shi*, 1959, **13**, Aug., 771–774) Measurements at 1550° showed both As and Sn to increase C activity. Equations for graphite solubility are given and interaction parameters at saturation are indicated.

Studies on a martensitic high-chromium cast iron A. Vilain and J. Marlot (*Publ. Assoc. Ing. Faculté Polytechn. Mons*, 1960, (2), 16–24) The principles and uses of methods employed in these studies are described. The effects of varying the Ni and Cr content on the mechanical properties is discussed as well as resulting micro-structures. A eutectic, martensitic cast iron which is very hard yet not very brittle is obtained with 5·5%Ni and 5·5–6·5%Cr.

Quality of structural steels W. Barr (*Building with Steel*, 1960, **1**, No.3, 4–7) A discussion of factors in choice and use, and fabrication and rolling are considered.—C.V.

Microstructures and notes on carbon steels made to B.S.3100: 1957: 592 Grade B T. Bailey and J. Turton (*Brit. Found.*, 1960, **53**, Oct., 439–442) The range of properties and microstructures of steel castings to BS.592 Grade B containing 0·35%C max., 1·0%Mn are presented.—A.D.H.

High carbon steels C. E. Mavrocordatos (*Engineer Foundryman*, 1960, **25**, Feb., 39–40) Given the same cooling rate, a given size of plate and depending on the carbon content the low carbon plate will on cooling after welding transform at a high temp. while the high carbon plate may transform at a very low tem. when the steel is very rigid and cannot accommodate the stresses involved. The most fundamental help in welding high carbon steel is a very generous preheat and as prolonged a post heat as possible which has the effect of reducing the rate of cooling and thus allowing transformation to take place at an elevated temp. where the steel is plastic.

Columbium treated, mild carbon semi-killed steels C. L. Altenburger (*AISI preprint*, 1960, pp.20) Moderate quantities of Nb in the form of Fe–Nb are added to mild carbon steels for the purpose of increasing their strength; to preserve the excellent weldability of mild steels at these higher strength levels; to provide for good formability and to provide a level of toughness that is equal to, or better than, mild carbon steels. These numerous objectives are attainable by a proper balance of other elements of the steel chemistry consistent with

the characteristics of the mill on which the steel is rolled. Steels suitable for general distribution, it is considered, must be easily weldable and formable and have good toughness.—R.S.F.C.

High-strength 12%Cr steels K. J. Irvine and J. D. Murray (*Eng. Mat. Des.*, 1960, **3**, Oct., 606–614) An extended account of the Jethete series of steels with extensive physical and mechanical test data.

Pressure vessel steels J. Glen (*Brit. Power Eng.*, 1960, **1**, Sept., 47–50) A review of steels for use at various temp. and of notch-tough steels is given. The ranges ~room temp. to 400°C, and higher are separately considered.

These steels were designed for the job (*Metals Prod.*, 1960, **104**, Sept. 21, 74–77, 82) Two new high-strength alloys by Firth-Vickers Stainless Steels Ltd, developed out of the experience of building the Bristol type 188 supersonic research plane, with details of the factors involved and cognate problems to be satisfied, are described.—S.H.-S.

Studies of corrosion-resisting and heat-resisting alloy steels M. Mizuno (*Tetsu to Hagane*, 1960, **46**, Aug., 1024–1035) [In Japanese] A review (13 refs).—K.E.J.

Progress in stainless and heat resisting steels J. Lomas (*Eng. Boiler House Rev.*, 1960, **75**, Oct., 326–328) A review with special reference to power-plant materials and conditions.

Stainless steels and other ferrous alloys W. A. Luce and J. H. Peacock (*Ind. Eng. Chem.*, 1960, **52**, Oct., 881–885) A Materials of Construction review, with notes on fabrication and welding (56 refs).

Stainless Cr–Ni steels containing Mo and Cu M. Vyklický (*Hutn. Listy*, 1960, **15**, (9), 671–679) The object of the research was to develop a stainless steel with the highest corrosion resistance having a Ni content as low a possible. Corrosion properties of 11 steels made on the laboratory scale were studied and compared with data on steels of slightly differing compositions given in the literature. Sheet made from two steels containing 18, 8, 2, 3, and 21, 18, 3, 4% of Cr, Ni, Mo, and Cu respectively were found to have corrosion resistances and mechanical properties not inferior to the more expensive steel hitherto used for equivalent purposes, containing 21%Cr, 38%Ni, and 5·5%Mo.—P.F.

An austenitic stainless utility steel for CrNiMnN castings K. Löbl, A. Šustek, and K. Hýbek (*Slévárenství*, 1960, **8**, (9), 333–340) The development and properties of the steel with composition 0·11%C, 8–9%Mn, 0·045%P max., 0·030%S max., 4·5–5·0%Ni, 19–20%Cr, 0·3–0·5%Cu, and 0·20%N are described. The steel is economical in nickel, and is virtually equivalent to current 18/9 CrNi steels. It has good mechanical properties, can be welded reliably and is polishable. Applications are primarily for industrial fittings, high-pressure pumps, hydraulic turbine blades, etc. Foundry technology has been developed, and details are given.—P.F.

Acid resisting chromium–nickel–manganese steels with nitrogen additions H. Serwicki and J. Marchwica (*Hutnik*, 1960, **27**, (10), 379–384) After considering austenitic Cr–Ni–Mn steels with and without nitrogen additions, the authors concentrate on the nitrogen additions as an austenitizing agent with reduced Ni content. An experiment was carried out and its positive results encourage the authors to commence a tentative replacement of 1H18N9T with this cheaper acid-resisting steel.

New 'super-weldable' stainless coming F. C. Hull (*Chem. Eng.*, 1960, **67**, Aug. 22, 162–164) A study limited to the effect of alloying agents on cracking during metal solidification (weld metal, cast parts) showing how 18 alloying agents affect 'hot cracking' of 16Cr–20Ni stainless steel is presented, with an alloy blueprint for crack-resistant Cr–Ni steels.

Retrospect and activities of the Verein Deutscher Eisenhüttenleute K. Thomas (*Stahl Eisen*, 1960, **80**, Dec. 8, 1912–1920) A lecture to the centenary jubilee of the Verein Deutscher Eisenhüttenleute in which the author reviews the activities of the Verein during the last 100 years.—T.G.

METALLOGRAPHY

Principles of high temperature microscopy B. B. Brenden, H. W. Newkirk, jun., and J. L. Bates (*HW*–58303, 1959, June, pp.40; from *US Res. Rep.*, 1960, **33**, Jan. 15, 102) [No abstract].

Techniques for electron microscope studies of bainitic steels J. Eysymontt (*Prace Inst. Hutn.*, 1960, **5**, (12), 248–253) The purpose of the work was to formulate the best etching reagents for bainitic steels. Several were tested at constant concentration and varying etching times. The test results were obtained with alcohol solutions of trichloroacetic and nitric acids. The micrographs are interpreted.

The use of chromium replicas in electron microscopy J. Bryniarska (*Prace Inst. Hutn.*, 1960, **12**, (4), 212–214) It was found that varnish replicas were unsatisfactory. The advantages of Cr replicas are: simple preparation, lower reject rate, clearer resultant images, magnifications up to 11 000 times give satisfactory results, true structure reproduction is achieved and resistance in the electron steam is high; the main disadvantage is the comparatively low mechanical strength.

Metallographic considerations relating to diamond polished specimens H. Klemm and K. Wiegmann (*Werks. Korros.*, 1960, **11**, Dec., 739–743) Characteristics of the surface polished with diamond paste (*ibid.*, 1960, **11**, (8)) are discussed, with special reference to areas near hard inclusions, the advantages of working without water with structural components which react with water, and the reproduction of graphite.

A new method of determining carbides in steels L. Brhágek, A. Golonka, and K. Kurzova (*Hutn. Listy*, 1960, **15**, (9), 679–686) Attack of the electrolyte on carbides in the process of extracting them from steels tends to falsify results of analyses. The attack can be minimized by using the lowest possible current density and the shortest possible time compatible with correct sampling. Low alloy Cu–Ni–Mo–Cr, Cu–Ni–Mo–V–Cr, Mn–Cr, and Si–Cr–Mo steels were studied and optimum carbide extracting conditions were determined. Slightly more than 20 mg of steel is required for an analysis of the carbides; microanalytical methods are used in the chemical part of the work. The method is particularly suitable in determining finely dispersed unstable carbides.

Precipitation of carbides in unalloyed and low alloy steels R. M. Fisher (*Fourth International Conference on Electron Microscopy*, Berlin, 1958, Sept. 10–17, preprint, 580–588) Studies of the precipitation of carbides in steel have been an important application of electron microscopy for a number of years. Such studies continue to hold great interest because improvements in specimen techniques and in the performance of the microscope itself make it possible to obtain even more detailed information on carbide formation. This paper summarizes the result of electron metallographic studies of the precipitation of iron carbides during isothermal transformation of austenite to pearlite and bainite, during tempering of martensite following quenching, and during ageing of ferrite supersaturated with carbon.

Determination of cubic chromium carbide $Cr_{23}C_6$ in steel N. M. Popova and K. P. Sorokina (**Zavods. Lab.*, 1953, (9), 1033–1034) Separation of $Cr_{23}C_6$ and Fe_3W_3C in HCl in presence of H_2O_2 is used.

Size, manganese content, and Curie point of carbides extracted from manganese steel R. W. Gurry, J. Christakos, and L. S. Darken (*ASM Preprint*, 1960, (189), Oct., pp.12) Examination and analysis of carbide residues extracted electrolytically from tempered Mn steels has yielded: (a) the equilibrium distribution coefficient of Mn between cementite and ferrite as a function of tempering temp., and the Mn content of cementite; (b) the Curie point of cemenite as a function of Mn content, and (c) the particle size distribution of carbides from steels tempered over a wide range of time and temp.—S.H.-S.

The influence of inoculation on the number of manganese sulphide particles in cast iron J. H. Gittus (*Metallurgia*, 1960, **62**, Aug., 69–72) It was discovered and verified in the work described, that the number of MnS particles in flake-graphite iron castings was increased by inoculation, and that pouring temp. changes produced a similar but less marked effect.

Studies on carbides in steels by electrolytic isolation. II. On the concentration of alloying elements in the θ-phase of low alloy steels. III. On the partition of Cu between θ-phase and ferrite in bearing steel K. Miyauchi, K. Tasaka, M. Arakawa, and T. Kunitake (*Sumi. Met.*, 1960, **12**, Jan., 312–318; 319–322) II. Data are given for steels after isothermal treatment and after quenching and tempering. The concentration of Cr and Mo in the equilibrium conditions are in good agreement with calculation from the pure Fe–C–M system, but those of Mn and Ni are lower. III. The Cu content was small, between 0·01 and 0·03%. Cu is more concentrated in ferrite as temp. or time is increased during heat-treatment, this resembles the behaviour of other non-carbide-forming elements.—K.E.J.

Determination of titanium oxide inclusions [in low-carbon steel] Yu. T. Lukashevich-Duvanova and V. A. Urazove (*Izvest. AN Otdel. Tek. Nauk, Met. i Topliva*, 1959, (3), 108–112) The phase compositions of inclusions from Ti-containing low-C steel were worked out. Where Si is used in deoxidation, silicates containing titanate are formed which increases with Ti content of the metal.

Precipitation processes in copper-rich copper–iron alloys A. Boltax (*NMI*–1210, 1959, Aug., pp.43; from *US Res. Rep.*, 1960, **33**, Jan. 15, 103) [No abstract].

Austenitic grain size of cast steel P. Détrez (*Fonderie*, 1960, Sept., 383–391) Reasons for austenitic grain size determination are summarized. The MacQuaid-Ehn test is compared and contrasted with a chemical method using picric acid and Teepol (16 refs).—R.P.

Studies on austenite grain size control in iron and steel. I. Z. Takao and T. Shimose (*Suiyokwai-Shi*, 1955, **12**, June, 537–544) Austenitic grain size control in iron and steel were investigated as follows: (1) analytical methods for metallic Al and Al compounds (Al_2O_3, AlN) in iron and steel by the ester-halogen method were established. (2) austenite grain size control in pure iron melted *in vacuo*. A Tamman furnace in an A atmosphere was used for the above analytical methods. **II.** Z. Takao, T. Noda, K. Kunii, and H. Takada (**13**, Nov., 51–55) Following the previous work, the effects of Al on austenite grain size surface-hardening steel (SH50, SH85) melted in a vacuum high-frequency furnace and a 10-t basic electric furnace were investigated through the application of the ester-halogen method.

A study on the austenite grain growth of steel by means of the hot-stage microscope H. Sawamura, T. Mori, K. Fujita, and E. Ichise (*Suiyokwai-Shi*, 1958, **13**, Sept., 423–427) The phenomenon of isothermal grain growth was studied on two kinds of 0·5%C steel. The air etching method by use of a hot-stage microscope was adopted for revealing the austenite grain. Relationship between the austenite grain size and austenitizing temp. or austenitizing time was investigated and the activation energies for austenite grain growth were also calculated. The values of activation energy calculated from the data which were obtained by use of the air etching method are larger than that calculated from the data of other workers which were obtained by use of the MacQuaid-Ehn test or slow cooling method.—R.S.F.C.

What is new regarding grain formation in metals under stress and the origin of grain boundaries S. M. Oknov (*Izvest. VUZ Chern. Met.*, 1960, (1), 136–141) A summary of the opinions expressed in recent years on this subject, i.e. on the grain structure of metals and on the origin of the grain boundaries, which play a great role in the stability of metals to heat. Some authors mention the presence of microscopic pores along the boundaries of the original grains due to an insufficient supply of metal during solidification from the fused mass. The dendritic crystal growth may be due to the liquid metal in the interaxial spaces, which are the sources of liquid metal supply. The occurrence of vacancies as well as of segregations is unavoidable in the growth of the dendritic crystals, but these do not occur at the places of growth but where the crystallization process ends, i.e. in the interaxial spaces.

Relations between type of crystal lattice, diffusion coefficients, interatomic bonds and recrystallization temperature S. S. Gorelik, A. M. Pavlov, and Ya. S. Umanskii (*Izvest. VUZ Chern. Met.*, 1960, (2), 95–99) Alloys of the Fe–Co system with K12 and K8 type lattices have been studied. The pronounced effect of the type of lattice on the diffusion rate of Fe and Co has been established. The diffusion coefficients in alloys with a body-centred lattice is greater by a factor of 7–10 than in alloys with a face-centred lattice. The variation in the recrystallization temp. and in the interatomic bonds is insignificant in a transition from a K8 lattice to a lattice of type K12.

The structure of the boundaries of the ferrite grain V. N. Gridnev (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 16–28) Factors considered include the metallographic characterization of the layers, the conditions of the formation and breakdown of boundary layers, and the processes of recrystallization (10 refs).—A.I.P.

Structural forms of crystallization and high temperature transformations in steels relating to peritectic domains S. M. Oknov (*Izvest. VUZ Chern. Met.*, 1960, (1), 155–166) The study of the structural forms natural to the primary high temperature $\delta \rightarrow \gamma$ transformation in carbon- and low-alloy steels, which refer to the peritectic domains has been neglected because in the usual micro-examination the metal is seen in which the traces of the original structure have disappeared to a large extent after the $\delta \rightarrow \gamma$ and the $\gamma \rightarrow \alpha$ transformations. A large series of X-ray examinations has therefore been carried out on stainless steels with a two-phase structure ($\delta + \gamma$), i.e. in the peritectic domain. Photomicrographs are given for steels of different compositions.

An investigation of the effect of aluminium and chromium additions on the kinetics of crystallization of α-irons L. N. Larikov (*Voprosy Fiz. Met. Metallov.*, 1960, (11), 67–73) The temp. and concentration relationship of the influence of Al and Cr additions on the rate of growth of recrystallization centres in plastically deformed ferrite is examined (16 refs).—A.I.P.

Investigation of the crystallography of diffusionless phase changes in steel C. M. Wayman (*AFOSR–TR–58–121; AD* 202922; *PB* 138654, 1958, Aug. 31, pp.10; from *US Res. Rep.*, 1960, **33,** Jan. 15, 81) A summary of reports on martensitic types of phase transformations (13 refs).

Transformation in steels during hardening E. I. Mirovskii (*Izvest. VUZ Chern. Met.*, 1960, (2), 118–120) During hardening, the transformation of the austenite begins on the steel reaching the A_2 temp. and then proceeds uninterruptedly up to the martensite transformation passing into the latter. Depending on the transformation temp. of the austenite, a different carbon concentration is found in the α-solution, which increases as the temp. is reduced.

The simultaneous influence of manganese and arsenic on transformations in iron–carbon alloys V. N. Svechnikov and A. K. Shurin (*Voprosy Fiz. Met. Metallov.*, 1960, (11), 53–60) Interest in the Fe–C–Mn–As system is linked with the fact that As is always found in steel made from Kerchen'skii iron ores. Alloys of 72 different compositions were examined and the main results are presented in the paper.

Influence of heat-treatment of white cast iron on its graphitization H. Sawamura, M. Ueda, and T. Yamazaki (*Suiyokwai-Shi*, 1958, **13,** Sept., 428–435) The effect of C, Si, Mn, P, S, and Cu on the M_s point of white cast iron was measured, and the fact was confirmed that the M_s point of the white cast iron cast for the manufacture of the commercial black heart malleable cast iron is ~90°C. Then the white cast iron, containing ~2·5%C and ~0·8%Si, was pre-treated by the following three processes before its graphitization at the first stage was measured at 820°C with a dilatometer: (1) common hardening method; (2) austempering at various temp., and (3) martempering at 100°C. The graphitization of the white cast iron austempered at temp. lower than 350°C, or martempered, was found to occur considerably more easily than that of the white cast iron in the as-cast state.

Transformation of the pearlitic structure of steel during rapid heating S. Gorczyca and J. Drabina (*Hutnik*, 1960, **27,** (6), 209–217) The initial pearlitic structure was obtained by austenitizing samples at 1200°C followed by isothermal transformation at 700, 650, or 580°C. The electrical resistance heating was done at various rates.

Composition of cementite during various heat-treatment processes on ball-bearing steel K. Seto (*Tetsu to Hagane*, 1960, **46,** Aug., 976–981) The Cr content in the primary eutectoid network decreased with rise of cooling rate. When specimens with a matrix of fine sorbitic pearlite were heated between A_1 and A_{cm}, the Cr in the non-dissolved cementite decreased with increase of temp. and time at the higher but increased at lower temp. With specimens having globular cementite, the Cr content increased with temp. (12 refs).—K.E.J.

Particulars of austenite transformation and formation of cold cracks on fusion welding N. N. Rykaline and M. K. Chorchorov (*Soud. Techn. Connexes*, 1960, **14,** Sept.–Oct., 335–347) A study is described of structural changes in base metal and weld metal, using an equipment for reproducing thermal cycles in the heat-affected zone during welding. The effects of heating and cooling rates in the Ac and Ac_3 temp. ranges on the mechanism of austenite transformation are discussed. Cold cracks are prevented by choosing a suitable welding process and conditions.—R.P.

Stabilization of austenite above M_s M. Izumiyama (*Nippon Kinzoku*, 1960, **24,** Jan., 58–62) Investigations were made on 1%C, 5%Ni steel. Stabilization increases with the amount of martensite, but does not depend on its presence. Stabilization can occur without prior decomposition of austenite into bainite or martensite, and reflects an internal rearrangement during retarded cooling or isothermal holding (23 refs).—K.E.J.

Isothermal transformation of austenite in tool steels under induction heating I. N. Kidin and Yu. A. Bashnin (*Izvest. VUZ Chern. Met.*, 1960, (1), 147–151) Induction heating of certain types of steel under optimum conditions reduce appreciably the stability of austenite formed with induction heating. The stability of this austenite is conditioned, in addition to chemical composition, mainly by the process of austenization (rate of heating and the domains of phase transformation and temp.) and shows itself to a large extent in the presence of the initial stages of decay. Induction heating reduces the stability of austenite more rapidly in the intermediate domains than in the pearlitic zone.

Studies of the transformation of austenite in low-carbon bainitic steels during continuous cooling W. Ciss (*Prace Inst. Hutn.*, 1960, **5,** (12), 223–237) During research on low carbon bainitic steels, kinetics of transformations of austenite were studied. Both dilatometric (Constant's ADAMEL apparatus) and metallographic methods were used. The results confirmed the existence of great possibilities of development of low-carbon bainitic steels, at any rate with regard to critical cross-sections of heat-treated parts. At the same time the results stress the necessity of studies of transformation characteristics of undercooled austenite.

The decomposition of austenite in 4340 steel during cooling E. P. Klier and T. H. Yeh (*ASM Preprint*, 1960, (103), Oct., pp.19) Several hardenability tests, with determination of the cooling and isothermal transformation diagrams for several 4340 steels, have shown that hardenability increases due to stepped austenitizing in 4340 steel are dependent on the austenitizing temp. and also result from suppression of ferrite precipitation in early stages of cooling in the high sub-critical temp. range.—S.H.-S.

Concerning the influence of carbon content and initial structure on the temperature of austenite formation in carbon iron alloys at high heating rates V. N. Svechnikov, V. N. Gridnev, and Yu. A. Kocherzhinskii (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 42–43) Electric heating at rates of between 20 and 200°C/s are compared with reference to two initial conditions: after annealing at 950°C and after quenching from 950°C in water.—A.I.P.

The rate of martensitic formation W. Ciss (*Prace Inst. Hutn.*, 1960, **12,** (4), 181–191) The work done to date is reviewed and the crystallographic, kinetic, and theoretical aspects of martensitic transformation are discussed in relation to the rate of martensitic setting. The work done in the last 30 years to establish the setting time is traced up to the latest result. The time is found to be less than $1 \cdot 10^{-7}$ s.

Concerning the thermodynamics of the martensite transformation V. N. Gridnev and V. I. Trefilov (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 29–41) The isothermal slowing down of the transformation of austenite into martensite is considered. At a certain temp. this transformation is completed after the formation of a certain amount of martensite. The equation of the martensite curve is also considered (19 refs).—A.I.P.

On the relation between superlattice FeCr (α'_{1-1}) and compound σ-phase in the Fe–Cr system S. Takeda and N. Nagai (*Suiyokwai-Shi*, 1955, **12,** June, 505–512) Difference in various properties and forming conditions between σ-phase, a non-magnetic compound, and FeCr (α'_{1-1}), one of the ferromagnetic superlattices in the Fe–Cr system, discovered by the present authors, were thoroughly studied. σ-phase is formed from α-solid solution at high temp. near 800°, while superlattice α'_{1-1} is formed from supercooled α at lower temp. near 500° by prolonged annealing. The latter however, transforms finally into the former by further annealing. From these results, it was concluded that the superlattice (FeCr (α'_{1-1}) is a metastable and intermediate phase between the disordered solid solution α and the stable compound σ.

Effect of heat-treatment upon the formation of the meta-compound Fe_2Cr (τ-phase) in the Fe–Cr system S. Takeda and N. Nagai (*Suiyokwai-Shi*, 1958, **13,** Sept., 468–471) Effect of modes of heat-treatment, that is, of isothermal heating temp. and time upon the formation of Fe_2Cr (τ-phase), one of the meta-compounds in the Fe–Cr system, formerly discovered by the present authors, was investigated by means of microscopical observation as well as by measurements of hardness, electric resistance, and intensity of magnetization at room temp. It is found that τ-phase is formed from supercooled α-phase by prolonged annealing at about 450–550°C, but it passes through the state of superlattice α′-phase on the way, and also the higher the heating temp. below the Te point, the easier is its formation.—R.S.F.C.

The influence of defects of crystalline structure on the breakdown and control of solid solution of cobalt and iron I. Ya. Dekhtyar and A. M. Shalaev (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 91–100) A thorough investigation was made, the results of which are presented in diagrams, tables, and equations. The conclusion is drawn that defects of crystalline structure have a marked effect on the speed of phase transformations (12 refs).—A.I.P.

The nature of the short range order of alloys of the Fe–Cr system P. O. Suprunenko (*Ukrain. Fiz. Khim.*, 1958, **3,** (5), 673–677) A preliminary high temp. anneal of alloys with 45, 47, and 49 at·%Cr increased the Curie point and specific conductivity throughout the temp. range. The results are discussed.

Thermodynamic properties of Fe–Cr system alloys A. G. Lesnik (*Voprosy Fiz. Met Metallov.*, 1960, (11), 3–21) Factors discussed include fusibility, thermodynamic activities, the use of an approximation of regular solutions to the analysis of curves of the equilibrium α-phase⇌σ-phase and solid-phase ⇌liquid phase, and the statistical theory of the disintegration of the α-phase of the Fe–Cr system with the appearance of an intermediate state (31 refs).

A more accurate determination of the diagram of the phase equilibria of the Fe–Zr system V. N. Svechnikov and A. Ts. Spektor (*Voprosy Fiz. Met. Metallov.*, 1960, (11), 30–35) The most significant result of this investigation was a new determination of the temp. of triple point (second fusion point), which the authors found at 1345°C.—A.I.P.

A diagram of the iron–arsenic system V. N. Svechnikov and A. K. Shurin (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 51–57) A review of the literature is given and a diagram is proposed by the authors, which confirms the

presence of eutectic transformation. The eutectic alloy contains 30·3%As and the eutectic breakdown is determined at 827°C. The phases entering the eutectic state are a solid solution of As in iron with a 6·8%As content and (presumably) compound formation of Fe_2As (40·1%As).—A.L.P.

The iron–carbon–arsenic system A. K. Shurin and V. N. Svechnikov (*Voprosy Fiz. Met. Metallov.*, 1957, (8), 58–64) An investigation was carried out into the ternary system Fe–C–As. Starting materials were metallic arsenic, Armco iron, and electrolytic iron. Experiments were made with various As contents. Many of the results are presented graphically.

Studies on the titanium–silver–iron alloys. I. Measurement of Young's modulus of titanium–silver–iron alloys. II. Studies on some mechanical properties of titanium–silver–iron alloys I. Miura and T. Takaai (*Nippon Kinzoku*, 1960, **24**, Jan., 1–4, 5–8) I. Young's modulus of the alloys containing 0·5%Fe varied with Ag content, but not of those containing 2% and 4%Fe. The value for water-quenched specimens was 5–20% lower than for annealed specimens. Cold-rolling followed by annealing did not affect Young's modulus (18 refs). II. For alloys containing 1, 2, and 4%Fe, values are given for the Kb values of cantilevered specimens, Vickers pyramid hardness, tensile strength, and elongation, for water-quenched specimens and fully-annealed and slowly-cooled specimens.—K.E.J.

The systems Y–Fe, Y–Ni and Y–Cu R. F. Domagala, J. J. Rausch, and D. W. Levinson (*ASM Preprint*, 1960, (187), Oct., pp.19) To determine phase relationships in the binary systems Y–Fe, Y–Ni, and Y–Cu, arc-melted alloys were heat-treated at appropriate temp. intervals, water quenched, and studied metallographically. The results of the studies, coupled with complementary X-ray and melting point work, permitted the construction of the three binary diagrams.—S.H.-S.

The effect of impurities on iron–chromium–yttrium alloys R. W. Endebrock, W. Chubb, E. L. Foster, and R. F. Dickerson (*BMI*–1338, 1959, April, pp.14; from *US Res. Rep.*, 1960, **33**, Jan. 15, 102) (No abstract).

CORROSION

The corrosion of metals (*Corros. Prev.*, 1960, **7**, Sept., 31–34, 58) A series of research investigations currently being carried out by the National Chemical Laboratory on water circulation systems, corrosion of tubes in Scotch marine boilers, corrosion inhibition, oxidation, atmospheric corrosion, underground, and microbiological corrosion, with their relative techniques, are briefly reviewed.

Corrosion problems and their treatment. Part I (*Corros. Prev.*, 1960, **7**, Sept., *Corros. Eng.*, iv–viii) A survey, first of a series of articles, giving a summary of various structures and materials attacked by corrosion and the relative merits of anti-corrosion techniques, presented in tabulated form.—S.H.-S.

Investigation on 'active iron'. Part II. Techniques used in studying reactivity G. V. L. N. Murty and T. R. Ramaswami (*Metallurgia*, 1960, **62**, Nov., 207–209) A description is given of the design of apparatus for reacting active iron with water or a solution of Na citrate and measuring the evolved gases at atmospheric pressure over water. A method of determining iron in the presence of a large excess of Na citrate is described.

Pitting corrosion, cause, effect, detection and prevention F. P. A. Robinson (*Corros. Techn.*, 1960, **7**, Aug., 237–239, 266) A review of the subject containing the results of experiments by the author on the corrosion pitting of stainless steels.

Fretting P. L. Teed (*Met. Rev.*, 1960, **5**, (19), 267–295) A review, covering various mechanical and physical aspects of fretting, fretting-corrosion resistance of various materials under dry conditions, and engineering design as a means of minimizing fretting, with the final general conclusion that current knowledge on the subject is most unsatisfactory, and, in part, due to metallurgical neglect (55 refs).—S.H.-S.

Fretting and corrosion P. L. Teed (*New Sci.*, 1960, **8**, Sept. 22, 776–779) These phenomena involve the abrasion of metallic surfaces; this may be to an infinitesimal extent but may be sufficient to impair resistance to fatigue. The fretting-corrosion resistance of some 50 metal pairs is examined (Al on Al, Al on cast Fe, Sb on steel, Zn on cast Fe, etc.), the findings being grouped as 'low', 'medium', and 'high'; it is considered that at this stage a satisfactory solution to a great number of fretting problems cannot be achieved except by realistic experiment.—C.V.

Cavitation erosion—a review of present knowledge D. J. Godfrey (*DSIR, TIDU* 1960, pp.14; from List No.1011).

Microbially induced corrosion W. Summer (*Corros. Techn.*, 1960, **7**, Sept., 287–288) A discussion of the metabolic principles involved, the type of corrosion to be expected, and methods of prevention.

Soil micro-organisms in relation to corrosion and cathodic protection J. O. Harris (*Corros. Techn.*, 1960, **7**, Aug., 250–253) Data obtained in research carried out by Kansas State University, with particular reference to deterioration due to micro-organisms found in soil in the pipeline ditch, i.e. in disturbed soil (10 refs).

Lime deposition on cold- and hot-water pipes made of copper and iron L. W. Haase (*Werks. Korros.*, 1960, **11**, Dec., 737–739) The mechanism of the formation of calcareous deposits in water pipes is discussed.

Cavitation erosion on screw propellers N. C. Astrup (*Acta Polytech. Scand.*, 1960, *ME* 7, (280) pp.16) [In English] Design and other factors for their protection are discussed.

Stress-corrosion failure of austenitic stainless steel A. B. Chatterjee and B. R. Nijhawan (*NML Techn. J.*, 1960, **2**, Aug., 20–25) Stabilized steels of this nature are not susceptible to failure by intergranular corrosion but the presence of Ti or Nb does not prevent stress corrosion. Failure of austenitic stainless steel from this cause in the presence of Cl-ions is known and industrial failure of this material in 2–5%H_2SO_4+$(NH_4)_2SO_4$ at 90–100° was examined and attributed to this cause.—C.V.

Corrosion of welded steel pump column piping handling acid mine water F. P. A. Robinson (*Eng. Found.*, 1960, **26**, Aug. 1. 29–32) Corrosion was most severe at the top sections of the pumping column and the occurrence of idle periods appears to increase corrosion; water-hammer introduces severe stressing and thus will accelerate corrosion. This state is more severe with reciprocating than with centrifugal pumps; electrolytic action is also mentioned as well as the presence of residual stresses. Substitution of the present pipes by corrosion-resistant alloys, cathodic treatment, water-treatment, and stress relieving heat-treatment of the pipes are all considered. The most effective would appear to be an internal protective coating, non-reactive to this water, possessing satisfactory mechanical properties such as toughness and resistance to wear and abrasion. Galvanizing has proved effective but is only temporary. The internal spraying of the 10in pipes with Zn and Al is also considered and although alkyd and epoxy or vinyl resins are corrosion resisting, the question of abrasion is still a cogent one.—C.V.

Water-treatment, corrosion and internal-deposit studies for Eddystone R. C. Ulmer, H. A. Grabowski, and R. C. Patterson (*Trans. ASME, J. Eng. Power*, 1960, **82A**, Oct., 264–274) Tests carried out on the feed water for a large boiler plant are detailed.

Influence of surface layers on the sensitivity to stress corrosion of austenitic and high-strength steels E. Baerlecken and K. Lorenz (*Werks. Korros.*, 1960, **11**, Dec., 744–749) The tendency of austenitic steels to stress corrosion is a function of their composition; steels containing ferrite are in general less sensitive, as the ferrite is attacked preferentially, and the austenite is cathodically protected. Cr plating provides a ferritic zone rich in Cr, which can act as an anode referred to the parent metal. The mechanism of stress corrosion of high-tensile ferritic steels in acid solutions containing H_2 is described in terms of H_2 penetration (14 refs).

Time–temperature parameters affecting corrosion of 18Cr–8Ni weld metals T. J. Moore (*Weld. J.*, 1960, **39**, May, 199s–204s) Boiling HNO_3 corrosion tests showed that ageing at 800–1100°F for long periods sensitized the weld metal much more severely than the conventional (1200°F) ageing temp. The effect of carbon content was investigated, and a promising stabilizing heat-treatment was used.

Corrosion evaluation tests of: I. Austenitic stainless steel. II. Welded austenitic stainless steel A. P. Krijff and A. de Visser (*UK Atomic Energy Authority, IGRL–T/C–109*, 1960, pp.24) I. Reviewing the laboratory methods of corrosion testing of austenitic stainless steels, the advantages of the boiling nitric acid test are outlined. The results of laboratory tests on different types of stainless steel plate material are dealt with. II. A survey is given from the method of corrosion testing of welded austenitic stainless steel used in the laboratory. The influence of plate material properties on the test results is outlined, as well as the influence of plate thickness.

Ductile and anticorrosive properties of cold-rolled annealed sheet steel of type 1Kh18N9T V. K. Barzii (*Stal'*, 1960, (12), 1134–1135) Cold-rolled sheet was tested, annealed, and hardened, for weight loss in HNO_3. The heat-affected zone is attacked more rapidly after hardening. Changes in the GOST specification are advocated.

Corrosion fatigue strength under combined stresses K. Endo and Y. Miyao (*Proc. 1st Japan Congress on Testing Materials*, 1958, 17–20) Equipment and testing techniques are described for the corrosion fatigue testing of a normalized medium C steel under combined bending and torsion with various cycle frequencies. From the results, relations between corrosion fatigue strengths under tension and compression are considered (10 refs).

A study of the onset of fatigue damage due to fretting A. J. Fenner and J. E. Field (*Trans. NE Coast Eng. Shipb.*, 1959–60, **76**, 183–228) Early stages were studied on an Al alloy.

Corrosion in circulating water systems C. O. Smith (*Brit. Power Eng.*, 1960, **1**, Aug., 61–64) A brief review of inhibitors with notes on corrosion in condenser systems.—C.V.

Corrosion inhibitors for industrial water treatment J. I. Bregman (*Ind. Eng. Chem.*, **52**, July, 53A–54A) A brief survey indicates that no universal corrosion inhibitor exists, that organic inhibitors are replacing inorganic ones to a very great extent, that a marked decrease in corrosion rate is evident when metallic cations are added to synergized polyphosphate, with a review of various ideas for specialized cases.—S.H.-S.

Inhibitors of the corrosion of iron. I. Effect of the cation P. Beckmann and J. E. O. Mayne (*J. Appl. Chem.*, 1960, **10**, Oct., 417–419) The inhibitive properties of the hydroxides of Na, Ca, Ba, Zn, and Pb and a range of salts of benzoic, cinnamic, α-naphthoic, acetic, butyric, and chloric acids were examined, and the lowest concentrations at which corrosion was inhibited described and discussed. It was concluded from a limited number of experiments that the lead salts of azeliac, suberic, and pelargonic acids were more efficient inhibitors than the corresponding calcium salts, which were more effective than the sodium salts.—S.H.-S.

Inhibitors of the corrosion of iron. II. Efficiency of the sodium, calcium, and lead salts of long chain fatty acids J. E. O. Mayne and E. H. Ramshaw (*J. Appl. Chem.*, 1960, **10**, Oct., 419–422) The inhibitive properties of the Na, Ca, and Pb salts of caproic, oenanthic, caprylic, pelargonic, capric, suberic, azelaic, and sebacic acids were examined in the pH range 4·0–6·0 at concentrations 10^{-5} to 10^{-2}N. The inhibitive efficiency increased with the length of the carbon chain up to a maximum at 8–9 carbon atoms. For a given acid the Pb salt was more efficient than either the Na or the Ca salt. The most inhibitive salts were lead suberate and azelate.—S.H.-S.

Selenites and tellurites as corrosion inhibitors B. Dev and B. D. Jain (*J. Sci. Ind. Res.*, 1960, **19B**, Oct., 408) Corrosion of steel by tap water is inhibited by 0·05%K_2SeO_3 or by 0·2%K_2TeO_3.

Corrosion inhibitors in refinery process streams D. L. Burns, R. L. Hildebrand, and

P. D. Thomas (*Corros. Techn.*, 1960, **7**, Aug., 240–244) Mechanism of corrosion inhibition, temp. limitations, detergent action, and chemical composition of high molecular weight organic inhibitors are reviewed, with reference to the literature (26 refs).

Theoretical principles and concepts of cathodic corrosion protection by impressed current and sacrificial anodes H. Kaesche (*Korrosion II, Kathodischer Korrosionschutz*, Verlag Chemie, 1959, **3–36**, 182–185) The electrochemistry of the mixed electrode, principles of cathodic protection by active anodes and impressed current, harmful side effects, electrochemical criteria of the effectiveness of cathodic protection, cathodic protection by electroplating, and anodic protection are reviewed and discussed.

Preventing corrosion of steel structures exposed to a marine atmosphere K. W. Dobinson (*J. Inst. Eng., Australia*, 1960, **32**, Sept., 183–188) A general discussion, methods of testing are described, and suitable coatings, their application and testing are given.—C.V.

Cathodic protection with active anodes against corrosion by soft water W. Rausch (*Korrosion II, Kathodischer Korrosionschutz*, Verlag Chemie, 1959, 37–59) The use of Zn anodes and the influence of Mg anodes on the rate of corrosion of the protected metal, on the formation of the protective layer and the water composition are discussed, and the planning of cathodic protection equipment is outlined.

Cathodic corrosion protection with active anodes against corrosion by seawater J. Lepper (*Korrosion II, Kathodischer Korrosionschutz*, Verlag Chemie, 1959, 60–92) Topics dealt with include: seawater as an electrolyte; the cathodic protective film; the protection of ships' hulls, steel structures, and ballast tanks.

Cathodic protection of underground structural members H. Klas (*Korrosion II, Kathodischer Korrosionschutz*, Verlag Chemie, 1959, 93–106) The economics of the method, the influence of secondary polarization, and problems connected with the process are considered.

Economic problems in corrosion protection F. Trojánek (*Werks. Korros.*, 1960, **11**, Dec., 756–760) It may not always be necessary to obtain absolute protection against corrosion in a given environment. The need for considering risks of corrosion and other forms of attack in relation to the various costs involved is discussed.

Corrosion symposium—protection of gas plant and equipment (*Corros. Techn.*, 1960, **7**, Nov., 360–367) Abstracts are given of the following papers presented at the joint symposium held in Sept. 1960, at Birmingham, by the Corrosion Group of SCI, the Institution of Gas Engineers, and the Birmingham College of Advanced Technology: **Principles and applications of cathodic protection** K. A. Spencer; **Cast iron and corrosion in the gas industry** H. H. Collins; **Corrosion and the gas consumer** F. C. Moody and C. H. Purkis; **Sprayed metal coatings in the gas industry** R. E. Mansford; **Organic protective coatings** A. T. S. Rudram.

Conditions for the cathodic corrosion protection of metals M. Pourbaix (*Werks. Korros.*, 1960, **11**, Dec., 761–766) The mechanism of cathodic protection is outlined, and some diagrams are reproduced from an 'atlas of electrochemical equilibria' which is under preparation, and which indicates for 43 metals and metalloids the electrode potentials and pH values which should produce corrosion, passivity, or immunity (10 refs).

Corrosion prevention in sea water flash distillation plant W. Smith (*Corros. Techn.*, 1960, **7**, Sept., 288–289) A brief description of the Aquaflash seawater distillation plant being built at the Cardon refinery of Compania Shell de Venezuela is followed by an account of the special corrosion problems encountered and their solution. Direct injection of heating steam into sea water feed is used to eliminate heat-transfer surfaces to which scale could adhere. The heat input unit is also designed to degasify the feed, and so remove CO_2 and O_2 from the plant.

Packaging metallic goods for export—procedures to avoid corrosion T. H. Dudley (*Corros. Techn.*, 1960, **7**, Aug., 245–247, 266) Factors influencing corrosion in the country of use—climate and terrain, means of transport, and measures of corrosion protection against the factors enumerated are considered.

Shot peening for protection against stress corrosion cracking H. Suss (*KAPL–M–HOS–9*, 1959, Sept. 18, pp.15; from *Nucl. Sci. Abs.*, 1960, **14**, Jan. 15, 75–76) Hardened AISI 410 stainless can be protected in high-purity waters by shot peening.

Bacterial corrosion of underground pipes L. T. Minchin (*Coke Gas*, 1960, **22**, Sept., 392–397, and 411) A study of various methods of pipe protection against different types of corrosion in Britain, Holland, and Belgium, and the USA in which the use of the redox potential and its application to different classes of soils and bacterial contamination is discussed.—S.H.-S.

ANALYSIS

The importance of micro-analytical methods for metals H. Malissa (*Stahl Eisen*, 1961, **81**, Jan. 5, 54–57) The author presents a review of trace analytical methods, of qualitative methods of micro-analysis, spot tests, and finally the various methods of quantitative micro-analysis and stresses the ever increasing importance of micro-methods in the analytical laboratory (28 refs).—T.G.

Use of metal fluor-chromic indicator for the complexometric titration of metallic ions M. R. Verma and K. C. Agarwal (*J. Sci. Ind. Res.*, 1960, **19B**, Aug., 319–320) Cr^{3+} alone, or in the presence of dichromate and Fe^{3+} is titrated against chenta acid (complexone IV); and Th against EDTA (complexone III), Calcein being employed in both cases as a fluorescent indicator. With semi-micro quantities the method is satisfactory and it is suggested that it could be applied to coloured solutions which present difficulties with conventional indicators.

A simplified hot-extraction apparatus for the determination of hydrogen in steel C. E. A. Shanahan and F. Cooke (*JISI*, 1961, **198**, July, 257–262) [This issue].

Determination of gases in metals W. Stauffer (*Werks. Korros.*, 1960, **26**, Sept., 364–367) The determination of gases in ferrous and non-ferrous metals is discussed, with reference to the vacuum fusion and carrier gas techniques.

The determination of gases in steels P. Tyou and M. Lacomble (*Extrait du Compte-Rendu du XXXIe Congrès International de Chimie Industrielle*, 1958, Sept., 1–5) The reasons for, and importance of, routine determination of gases in steels are stressed. Methods for determining H_2, N_2, and O_2 are outlined. The limitations and errors of each method are discussed.—R.P.

The determination of oxygen in molten Thomas steel. Techniques used for sampling the liquid metal and gas analysis J. Marot and I. Harveng (*Rev. Mét.*, 1960, **57**, Nov., 991–997) It is considered that the Swinden bomb is the most suitable method of sampling Thomas steel. Of the analytical methods examined—vacuum melting under reducing conditions, Beegly's ester–halogen method and chemical methods—the first-named method appears to be more accurate but takes longer. Speed is increased by vacuum fusion under argon.

Some problems in the colorimetric determination of phosphorus Cheng Heng-yuan and Wang Wen-yun (*Acta Pedalogica Sinica*, 1958, **6**, (4), 257–261; from *Sci. Abs. China Techn.*, 1959, (3), 59) Molybdenum blue is more sensitive to colour changes than molybdenum yellow and is hence more suitable for the determination of samples with a lower content of P. Heating tends to hasten blue coloration as well as extending the acid range in which the coloration of molybdenum blue takes place. The optimum acid range for silicon molybdate is 0·001–0·01N and that for phospho-molybdate is 0·4–1·2N. The mutual interference of P and Si may be checked by adjusting the amount of tartrate used and also by adjusting the time of addition, viz. whether added before or after the addition of molybdic acid.

Simultaneous colorimetric determination of small amounts of phosphorus and silicon in iron and steel Tsai Hsien-feng (*Chemical World*, 1959, (1), 45–47; from *Sci. Abs. China Chem. Techn.*, 1959, (3), 59) P and Si may be separated by means of the acidity difference of the complex acid solution when undergoing reduction. This colorimetric separation is simple and reliable. The analytical error is within 3%. Ascorbic acid is used as a reducing agent. Appropriate figures and data are attached.

A rapid, accurate method for the determination of silicon in carbon and low-alloy steels and cast irons C. G. Westwood (*Metallurgia*, 1960, **62**, Nov., 227–232) A modification of the Regelsberger method is described, in which a HNO_3–H_2SO_4 soln. of the sample is treated with H_2O_2, fumed lightly, diluted and the Si flocculated by gelatine solution. Accurate results are obtained by a single evaporation.

Photometric determination of silicon in steel P. C. Pile (*BHP Tech. Bull.*, 1960, **4**, Nov., 22–25) The method used is essentially that of Sanders and Cramer but has been modified according to the concentration of Si; the ranges are, trace to 0·2%, trace to 0·6%, and 0·6–1·2%. With samples that dissolve readily, analysis can be carried out in 15 min. and thus the method can be employed on samples taken at the 'melt' on special heats. For routine work a Klett-Summerson colorimeter is used with a 66 filter; the wave-length at which the complex is measured is ~660 μ and calibration curves for the indicated ranges were prepared using matched test-tube cells. Over 20000 estimations have been carried out and such check analyses as have been done by standard gravimetric procedures show close agreement with the photometric figures.

The chelometric determination of aluminium, nickel and manganese without prior separation D. H. Wilkins (*Anal. Chim. Acta.*, 1960, **23**, Oct., 309–311) Hydroxyethylethylenediaminetriacetic acid is used for Al and Ni, and EDTA for Mn in the same solution. Methyl Calcein or Methyl Calcein Blue are used as indicators.

Stoicheiometry of titration of calcium, magnesium and manganese at low concentration with EDTA, with the metal indicators murexide and Eriochrome Black T O. Gjems (*Analyst*, 1960, **85**, Oct., 738–744).

Ion-exchange separation of titanium from steels and its determination with hydrogen peroxide V. T. Athavale, M. N. Nadkarni, and C. Venkateswarlu (*Anal. Chim. Acta*, 1960, **23**, Nov., 438–440) Ti is quantitatively separated from its associated elements in the steels as the fluoride complex using Amberlite IRA–400 and then determined by the usual peroxide method. The effect of varying the HCl/HF ratio on the retention of Ti is shown. V is partially retained with the Ti but on increasing the volume of the wash liquid the V is entirely removed.—C.V.

The colorimetric determination of molybdenum in the form of its complex B. I. Nabivanets (*Ukrain. Khim. Zhur.*, 1958, **24**, (6), 635–645) [In Russian] The use of various reducing agents and the influence of various factors on the complex were examined, and methods worked out for determination of Mo in WO_3 and in steels, using the complex. In the latter case ascorbic acid is used as the reducing agent.

Complexometric titration of zirconium using 4-sulpho-2-naphthalenazo-1 : 8-dihydroxy-2-nitrosonaphthalene-3 : 6-disulphonic acid S. K. Datta (*Chim. Anal.*, 1960, **42**, Nov., 562–564) Zn forms a reddish-brown soluble complex with the reagent. A process is described of titrating Zr with EDTA using this as indicator. A large number of cations can be tolerated and Th–Zr mixtures can be analysed quantitatively.

On the method of the chemical determination of tellurium in cast iron S. Morita and R. Ozaki (*Suiyokwai-Shi*, 1954, **12**, (5), 237–240) The method of determination of Te in cast iron by means of the SO_2-method was investigated. As the precipitation of metallic Te formed was delayed by Fe^{3+} in the solution, the authors studied methods for shortening the time necessary for passage of SO_2 through the solution.

Volumetric determination of uranium in the presence of high concentrations of iron T. J. Blalock (*US Bur. Mines, Rept. Invest.*, 5687, 1960, pp.9) The U is separated with excess HF.

Direct spectrometry in metallurgical laboratories W. Klimecki (*Hutnik*, 1960, **27**, (7–8), 269–273) The article deals with progress made in the field of spectrography during 1959. Most of the data is drawn from 12 German papers.

The influence of extraneous elements in D.C. arc spectra of ferrous alloys D. W. Jensen and J. F. Young (*WADC Tech. Rep.* 52–168; *ATI*–173043; *PB* 139068, 1952, July, pp.42; from *US Res. Rep.*, 1960, **33**, Jan. 15, 81) Homogeneous alloys were manufactured, and Mn, Si, Ni, Cr, Mo, V, Al, and Cu were used as alloying additions to an iron matrix, in amounts normally found in low-alloy steels (15 refs).

Spectrophotometric studies of iron (III)-oxine *N*-oxide complex A. N. Bhat and B. D. Jain (*J. Sci. Indust. Res.*, 1960, **19B**, Aug., 295–297) This is formed by the addition of an alcoholic solution of oxine *N*-oxide to ferric perchlorate in the pH range 0·5–8·4; the molar ratio of Fe to the oxine in the complex is determined by a modified Job's method of continuous variation and has been verified by the slope ratio method. In the pH range 0·5–3·5 the molar ratio is 1:1 forming a brown-green complex with max. absorption at 510 mμ. This differs from an earlier reported finding of 1:3. The colour is stable for 48 h and obeys Beer's law in the conc. range 2·0–5·5 ppm Fe. Between pH 6·5–8·4 a yellow-red complex occurs with absorption max. between 425–430 mμ; this indicates the formation of a new complex. That formed between 3·6–6·0 pH shows absorption max. at 510 and 430 mμ suggesting the product formed is a mixture.—C.V.

Spectrophotometric determination of titanium in high-temperature alloys N. M. Silverstone and B. B. Bach (*Metallurgia*, 1960, **62**, Aug., 81–82) Ti is separated as hydroxide, interference due to Mo, Cr, and Fe eliminated, H_2O_2 added, and Ti determined spectrophotometrically.

Simultaneous determination of silicon, manganese and magnesium in nodular cast iron by spectrometry Lee Hsien-cheng and Sun Chi-keng (*Chemical World*, 1959, (1), 48–51; from *Sci. Abs. China Chem. Techn.*, 1959, (3), 58) A spectrometric procedure for the simultaneous determination of Si, Mn, and Mg in nodular cast iron is described. The authors have also presented the working curves for these elements, the experimental data and statistics of analytical errors.—R.S.F.C.

The spectrophotometric determination of vanadium as molybdovanadic acid G. W. Wallace and M. G. Mellon (*Anal. Chim. Acta*, 1960, **23**, Oct., 355–362).

Spectrographic determination of boron in steel by a rotating electrode method M. K. Ghose, S. Pait, and B. C. Kar (*NML Techn. J.*, 1960, **2**, Aug., 12–14) High voltage ac intermittent arc is used for the spectrographic determination of B in steel (0·001% with a accuracy of ±5%). Details of sampling, electrodes, and development of plates are given.

Determination of small amounts of special elements in cast iron. V. Spectrophotometric determination of calcium in cast iron K. Ota (*Nippon Kinzoku*, 1960, **24**, Jan., 46–49) Optimum conditions are given for the photometric determination of Ca using Plasmo Corinth dye (Na 1-hydroxy-4-chloro-2:2-benzeneazo-1:8-dihydroxynaphthalene-3:6-disulphonate). The reagent can be preserved for 50 h without change. The method is suitable for 0·001–0·06%Ca in cast iron (16 refs).

Determination of alloyed elements in special steel by fluorescent X-ray spectrometry K. Momoki, S. Hirano, T. Koizumi, and F. Sawai (*Tetsu to Hagane*, 1960, **46**, Aug., 988–994) The method is simple, rapid and accurate, and suitable for routine analysis of a number of alloying elements in high-speed, super-heat-resistant, and other special steels. Details are given of the compositions covered for W, Mo, Co, V, Ni, Cr, and Nb.—K.E.J.

Spectrophotometric determination of microamounts of aluminium in iron and steel with chrome Azurol S H. Goto, Y. Kakita, and M. Hosoya (*Nippon Kinzoku*, 1960, **24**, Jan., 32–35) Most of the Fe is separated with methyl *iso*butyl ketone, the remaining Fe and Cu are masked with thioglycollic acid, and the absorbance is measured at 550 mμ. The method has several advantages over the aluminon method, and is suitable for 0·002–0·1%Al.

Method for the quantitative spectrochemical analysis of rocks, minerals, ores and other materials by a powder D–C arc technique H. Bastron, P. R. Barnett, and K. J. Murata (*US Geol. Survey, Bull.*, 1084–G, 1960, 165–182) A method especially valuable for the determination of minor constituents is described.

Applications of radioisotopes in metallurgical research H. L. Gibbs, C. H. Schack, and J. B. Clemmer (*US Bur. Mines Rep. Invest.*, 1960, (5689), pp.12) Hazards and precautions, availability of radioisotopes, layout of the laboratory, instruments and methods, and typical applications are discussed.—C.V.

Volumetric determination of Al_2O_3 in silicates I. A. Voïnovitch and A. Lefrane-Kouba (*Chim. Anal.*, 1960, **42**, Nov., 543–548) This study marks a first stage in the direct measurement of Al_2O_3 semi-direct measurement of Al_2O_3 based on the separation of Fe and Ti as cupferronates by simple filtration followed by volumetric estimation of Al_2O_3 with EDTA. The analysis can be used in complex cases, (silicates, rocks, etc.).

Rapid method of determining the principal elements of a natural silicate rock. Part II A. Behr, M. L. Blanchet, and L. Malaprade (*Chim. Anal.*, 1960, **42**, Nov., 557–561) The methods of determining silica, alumina, iron, lime, and magnesia in granite and basalt are described.

INDUSTRIAL USES AND APPLICATIONS

Stainless steel in building and in architectural decoration. III A. G. Amoroso (*Acciaio, Inossid*, 1960, **27**, (5), 501–510) This article describes two conferences held recently at Rome on the subject of modern American architecture and the prospects for greater increased use of stainless steel for this purpose. A list of new buildings in the USA together with the employment of stainless steel in their construction or decoration is given.

Japanese steel materials used for prestressed concrete K. Takeo and I. Miykawa (*Procs. of Symp. on Prestressed Concrete and Composite Beams. Science Council of Japan*, 1955, Nov., 6–14) [In English].

Metallic materials of construction for the chemical industry G. W. Brewer (*Corros. Prev.*, 1960, **7**, Nov., 35–39) A review. Ferrous and non-ferrous materials are included and welding is considered.—C.V.

Some steels which were specially developed for the watch and clockmaking industry and high-precision mechanisms, and their heat treatment A. Bernstein (*Schweizer Arch.*, 1960, **26**, Sept., 329–338) The composition, properties, and treatment of these steels are described.

Designing steel liners for light metal housings W. R. Crown (*Mach. Design*, 1960, **32**, Sept. 1, 117) Steel parts (bearings, seals, etc.) present in Al or Mg housings which operate at temp. considerably above assembly temp. require interference-fit steel liners; without these serious damage may arise. Design, material fastening, and assembly are discussed. Prior to assembly, liners are coated with Zn chromate paste which, apart from facilitating assembly provides additional dissimilar metals contact protection. The liners are then cooled in dry ice to −40°F and the housings heated to a max. 300°F for assembly.

Stainless steel bolts for aircraft E. Richter (**Luftfahrttechnik*, 1959, **5**, Feb. 15, 58–60) Stainless steel bolts have many advantages in aircraft construction. Materials for such bolts and their strengths are discussed together with the manufacture of stainless bolts and nuts. The danger of seizing is discussed in detail. Safety devices and self-locking bolts and nuts are also mentioned, and the application of 'PH steels' is touched on.—R.S.F.C.

Improved bolting materials for internal assembly of HRP components B. D. Draper (*CF*–59–10–69, 1959, Oct., pp.10; from *Nucl. Sci. Abs.*, 1960, **14**, Jan. 15, 80) An investigation was made to improve materials and practices used in the internal bolting of HRP components. Wire type stainless steel thread inserts were found to be corrosion resistant and non-galling, although somewhat difficult to instal and remove. These operations are especially troublesome if done remotely. Two alloys were found to be corrosion-resistant, nongalling, and of high strength: CD4MCu and Uniloy 19–9 DL. Other promising alloys, which however require additional testing, are AM–355, Timken 16–25–6, and Timken 16–15–6.

Steels used for atomic energy B. Watkins (*Swansea Met. Soc.*, Advance Copy, 1960, 1–29) A general account of selection, fabrication, and testing processes.

Steel problems in the supersonic T 188 Bristol Aircraft Co. Ltd (*Engineering*, 1960, **190**, Sept. 9, 334) The required material had to possess the highest possible elastic modulus, highest strength with ductility, freedom from stress corrosion, uniform properties in all directions, simplicity in post-fabrication heat-treatment, and good strength at high temp. 12Cr-stainless steel of the FV448 type is much used. Heat-treatment of the keel boom, 39 ft long, in this material required special precautions to maintain straightness; this was achieved by applying a hydraulic load to the bar until it had cooled below the critical temp. The same material was used for the mid-section of each engine nacelle consisting of three cylindrical forgings weighing 3–4 t each. In the major envelope of the fuselage, where there is a double curvature, a cold rolled Ti-stabilized 18Cr–9Ni stainless steel and Firth FDP are used. In forgings, ultra-high-tensile (110–120 t/in²) steels are employed. Despite the higher rate of hardening which makes working difficult, stainless steel was used for the rivets and even in the fully-hardened and tempered state (70–80 t/in²), these could be set easily by squeeze and percussion methods up to $\frac{5}{16}$ in dia.

HISTORICAL

Iron technology in the Swietokrzyskie Mountains between the 1st and 4th centuries J. Piaskowski (*Hutnik*, 1960, **27**, (6), 218–223) The article consists of the results of chemical and metallographic analysis of old iron objects found in the district. Microhardness distribution, grain size, and phosphorus content were studied, and in particular the extent to which carbon addition was successful. Some theories as to the method of manufacture are advanced. A certain amount of nitriding was observed but this was thought to be accidental.

The charcoal iron industry of East Denbighshire, 1630–1698 I. Edwards (*Transactions of the Denbighshire Historical Society*, 1960, **9**, 1–31). **The Early Ironworks of North-West Shropshire** (*Transactions of the Shropshire Historical Society*, 1961, 185–201) These papers trace the evaluation of the iron industry in East Denbighshire and the adjacent part of North-West Shropshire, in particular in the course of the 17th century. They considerably enlarge the scanty knowledge available by unearthing new historical evidence from the Longueville MSS preserved in the National Library of Wales at Aberystwyth. The principal market for the iron produced was the plateau of Birmingham where it supplied the numerous nailors. The most important ironmasters were the Myddletons, Kynastons, Lloyds, and Wilsons.—H.R.S.

Metallographic examination of ancient iron objects from the territory between the Oder and the basin of the Vistula river J. Piaskowski (*JISI*, 1961, **198**, July, 263–282) [This issue].

Report on research on the ancient nails which were used in the Horyu-Ji (1st report) H. Nishimura and N. Aoki (*Suiyokwai-Shi*, 1955, **13**, Nov., 39–44) The Horyu-Ji, being famous for the oldest temple and also the oldest wooden building in Japan, have been divided into sections for repair. The authors took some ancient nails from the Go-Ju-no-To (the five-storied Pagoda) and the Kon-Do (the Sanctuary) which have been rebuilt recently. The authors reported that the nails fell into four periods—the foundation period, 1000, the Middle age, 1158–1458, The Keicho period, 1604, and the Genroku period, 1696.

Ceramics in the Saugus blast furnace *circa* **1650** H. M. Kraner (*Refract. J.*, 1960, **36**, Aug., 245–247) Examination of the furnace site

revealed not only metallic items but rocks, mineral matter, and slags, etc. Early ironmakers knew that the gangue had to be fluxed; as the fuel was charcoal there was little gangue from that source; bog iron ore was mostly used, the main impurity being Si containing very little alumina or other matter; limestone, clam shells, or coral was used as flux and therefore the slag consisted principally of CaO, SiO_2, with a little Al_2O_3; some MnO and FeO was present since the slags were acid and as the furnace temp. was low. Analyses of the slags and bog ore samples are given; there were no S problems. Most iron furnaces of the 17th century used sandstone for the entire structure; here granite was employed, the inner portions of the walls being filled with rubble between the hot and cold faces. The nature of the sandstone lining is discussed together with the changes it had undergone in shrinking and cracking. The moulds and cores used in casting show that a sandy composition was used, grass and straw being employed to give resiliency to the core and to prevent the cracking which was so prevalent at the time. The sands used are discussed. Wrought iron was also produced.

A brief history of modern ferrous metallurgy. I. Birth of the Bessemerizing method M. Nakazawa (*Tetsu to Hagane*, 1960, **46,** Aug., 995–1009) [In Japanese] An historical review, including diagrams of original plant (16 refs).

The Dowlais story 1759–1959: old works and the new N. Woodhouse (*Dowlais Story*, 1959, pp.12) A series of articles on the history of the Guest, Keen Iron and Steel Co. to mark the bicentenary.

The development of metallurgical processes and their industrial application F. A. Springorum (**Stahl Eisen*, 1960, **80,** Dec. 8, 1838–1851) A lecture to the centenary jubilee of the Verein Deutscher Eisenhüttenleute. The author reviews the developments and changes that have taken place in the German iron and steel industry during the last 100 years. An extensive bibliography is appended.—T.G.

Examples from the history of the working of steel W. Ochel (**Stahl Eisen*, 1960, **80,** Dec. 8, 1852–1863) In this lecture to the centenary jubilee of the Verein Deutscher Eisenhüttenleute the author reviews the changes that have taken place in the working of ferrous metals during the last 100 years or so, with particular emphasis on rolling, including wire rod rolling.

Steel as a constructional material in technological development during the last century H. Kallen (**Stahl Eisen*, 1960, **80,** Dec. 8, 1864–1877) In this lecture to the centenary jubilee of the Verein Deutscher Eisenhüttenleute the author reviews the technological progress made in the improvement of the properties of steel and in testing and analysing its quality. The role played by metallurgical research on the development of steel is stressed.—T.G.

Samuel Walker E. N. Simons (*Metallurgia*, 1960, **62,** Aug., 73–74) An account of the development in the 18th century of the iron-founding business with which Samuel Walker was associated.

Ferrous-metallurgical commemoration days in 1961 H. Dickmann and G. Bauhoff (*Stahl Eisen*, 1961, **81,** Jan. 5, 51–54).—T.G.

ECONOMICS AND STATISTICS

The development of technical processes and their effect on the structure of the costs of production of iron and steel P. Rheinländer (**Stahl Eisen*, 1960, **80,** Dec. 8, 1878–1890) In this lecture to the centenary jubilee of the Verein Deutscher Eisenhüttenleute the author reviews the economic changes that have taken place during the last 100 years or so and the role employee relations have played during this time on the structure of the costs of production.—T.G.

The integration of production planning, electronic data processing, and process control W. F. Cartwright and G. W. Thomas (*JISI*, 1961, **198,** July, 250–256) [This issue].

The economics of rolling (*Iron Steel Rev.*, 1960, **4,** Sept., 35–42) A very general review, much of which is based on comparison of the production figures of 1952 with those of 1958. Some tables are given showing the steel and man-hour consumption in the production of various parts by casting and welding, by forging and welding (USSR), and in the production of rolled products. The figures for 1975 are forecast on the basis of the 1957 output.

Iron-smelting in Northern France as an aid to local industry and French prosperity J. Leclerc (*Mem. Soc. Ing. Civils France*, 1960, **113,** Sept., 37–52) A review, technical, historical, geographical, and economic, directed to proving that the Nord region of France contains all the conditions requisite for the ever-growing production of steel and the future prosperity of the industry based on the Dunkerque–Valenciennes axis.—S.H.-S.

The importance of the steel industry to the economy of the country C. M. Krüger (*S. African Mech. Eng.*, 1960, **10,** Sept., 27–34) A review, mainly economic.—C.V.

The Spanish steel industry (*Metallurgia*, 1960, **62,** Nov., 192–194) A summary of a financial survey made by the Spanish Ministry of Industry, in which future demands on the steel industry are forecast.

The planning of new metallurgical plants with regard to Polish conditions Z. Warczewski (*Hutnik*, 1960, **27,** (7–8), 259–269) The author points to the necessity for standardizing and normalizing new works. When giving orders outside Poland the guarantee clauses should be stated precisely and consideration given to such factors as the accommodation of the personnel. In addition the author gives some general outlines of modern steelworks and discusses the rising cost of manufacture, examining in particular the fuel costs.

New China in the world tin situation (*Tin*, 1960, Aug., 191–194) A review. Production is estimated at 30000 t per annum. Little is known about the tin smelting capacity but it is considered that China will require all her own tin, although according to the 1959 figures she exported some 23000 t mostly to the USSR.

Steel panorama of Latin America (*Bull. ILAFA*, 1960, **1,** Oct., 17–22) A documented and detailed review is presented, covering information on the possibilities and problems of the three countries of Argentina, Brazil, and Mexico. Future issues of ILAFA will carry similar reports on other Latin American countries.

Chile: Acquisition of ferro-manganese for the United States (*Bull. ILAFA*, 1960, **1,** Oct., 12) The Commodity Credit Corp., on 18 Oct. 1960, announced the proposed purchase from Chile of 32000 t of ferromanganese in exchange for North American agricultural products acquired by Chile.—S.H.-S.

The present situation and prospects of the Mexican steel industry F. González Vargas (*Bull. ILAFA*, 1960, **1,** Oct., 23–28) A comprehensive review of the raw material situation and of present production and prospects of the Mexican steel industry, is presented, and plans for new steelplants are briefly discussed.

MISCELLANEOUS

Tradition in an ever-changing world J. Pieper (*Stahl Eisen*, 1960, **80,** Dec. 8, 1922–1927) A lecture to the centenary jubilee of the Verein Deutscher Eisenhüttenleute.—T.G.

Some recent developments in graphite heat-exchangers and similar equipment A. Hilliard (*Industrial Carbon and Graphite*, 1958, reprint, 605–617).

Recovering manganese from mill rejects W. A. Stickney and C. W. Sanders (*US Bur. Mines, Rep. Invest.*, 1960, (5692), pp.11) Four samples were studied. It is shown that the use of an oil emulsion to recover Mn from certain fine-grained, complex minerals is technically feasible. Blending different types of feed allows materials which are themselves refractory to be treated by physical concentration methods. Consumption of reagents is relatively high and minimal quantities have not been established. However, the simplicity and adaptability make this process attractive. Sintering the concentrate to increase the grade is also discussed.—C.V.

Fused-salt electrorefining of vanadium F. R. Cattoir and D. H. Baker jun. (*US Bur. Mines, Rept. Invest.*, 5630, 1960, pp.11) The process was operated successfully.

Chromium V. B. Schneider (*Can. Mines, Canadian Mineral Industry*, 1959, Review 7, 1–7)—C.F.C.

Nickel C. C. Allen (*Can. Mines, Canadian Mineral Industry*, 1959, [Preliminary], *Review* 17, pp.11).

Manganese V. B. Schneider (*Can. Mines, Can. Mineral Industry*, 1959, *Review* 15, pp.8).

Quality control, impetus to industry D. R. Appel (*AISI*, 1960, Preprint, pp.13) A review in general terms, mostly on human factors.

Work-study today (*Found. Trade J.*, 1960, **109,** Aug. 25, 231–232) The increased output in a Belgian foundry as the result of this is discussed and compared with the outlook in Britain towards this subject.—C.V.

Steel workers and technical progress (*EPA Project No.*164, *Industrial version No.*2, 1959, June, 1–65) A study of workers' attitudes to technical developments.

Safety! Men at work I. G. Steel and N. H. Jones (*Railway Steel Topics*, 1960, **5,** Autumn, 54–61) Accidents in the steel industry and measures to avoid them are reviewed.

Changes in protein, sodium and potassium chloride concentrations in sera of workers subjected to heavy muscular work in excessive heat Y. Norimatu (*J. Lab. Hyg. Iron Steel Ind.*, 1960, **9,** Nov., 10–15) Five groups were studied. Serum protein increased considerably, the change being relative to the water loss. Chloride was above normal at first and then decreased with the severity of sweating; no significant change was noted in the Na but K showed a slight increase after the work-effort.

BOOK NOTICES

AMERICAN WELDING SOCIETY. '*Welding Handbook*'. 4th ed., Section 3. Special Welding Processes and Cutting. 9 × 6in, pp.500. 1960, London: Cleaver-Hume Press Ltd. (Price £3 12*s.*)

The Welding Handbook of the American Welding Society is firmly established as one of the most authoritative works on welding technology. In 1958 the Society announced that the increased scope and complexity of modern welding processes made it necessary to divide the Handbook into five parts and the latest section (Part III) deals with specialized welding techniques and cutting. Chapters are also included on such topics as Forge, Thermit, and Induction Welding, Surfacing and Metal Spraying. Other metal joining processes such as soldering, brazing, and adhesive bonding are also dealt with and the average welding engineer will be grateful for the detailed and comprehensive chapters on these methods of metal joining. The chapter on adhesive bonding is particularly good and may in fact be considered as a text-book in its own right, covering every aspect of the subject from the preparation of honeycomb structures to the production of laminates. A comprehensive section is also included on the welding of plastics, a field of welding technology which is far removed from its traditional metallurgical background.

In keeping with the previously established pattern of authorship each chapter has been compiled by a small committee of experts. The impression is given that the information contained in the text represents the latest and best practice and a comprehensive bibliography is also included in each of the chapters. Since the metallurgical features of the welding processes were fully dealt with in Part I the present volume does not approach the subject matter from a metallurgical aspect but deals with it on a practical basis. The treatment is extremely thorough, however, and the book is far from being a simple guide for welders.

As would be expected of one of the principal publications of the American Welding Society the presentation of the subject matter is excellent and the illustrations clear and informative. The price will probably place the book beyond the reach of the average student but for the practising welding engineer it will prove a worthwhile investment and it is certainly an essential

addition to the library of any establishment where modern welding techniques are used.
—J. F. MERCER.

BARTOCCI, A., and MARIANESCHI, E. '*I Metalli e l' Acciaio*'. 2nd ed. 10×7in, pp.xxvi+982. Illustrated. 1960, Terni: Poligrafico Alterocca. (Price L.10500.)

The first part (439 pages) of this book, after a brief history of metallurgy, reviews the physical, mechanical, and nuclear properties of metals, corrosion resistance, solidification phenomena, transformation and methods, testing and metallographic examination, heat-treatment, effects of deformation, and metal properties. The second part (520 pages) deals with steel, the properties of pure iron and the iron–carbon diagram, ironmaking, and the various steelmaking methods and casting techniques (including extremely brief elementary notes on continuous casting and vacuum casting). It also provides a useful chapter on Italian steel standards and information on hot working and heat-treatment, carbon steels, the effect of alloying elements, alloy structural and tool steels, and defects.

While there is little new information in this large well-illustrated book, its purpose is to supply a fairly comprehensive reference book for students of metallurgy and possibly others who wish to make a broad check on phenomena. The authors borrow widely from foreign sources and while its usefulness in this country might well be limited to those who are engaged in translating Italian metallurgical papers, it would obviously form a very useful reference tool for Italian metallurgical graduates and students.
—R. SEWELL.

CAYRON, R. '*Etude Theorique des Diagrammes d'Equilibre dans les systèmes Quaternaires*'. 12¼×10¼in, 2 vols., pp.iii+162, 78. Illustrated. 1960, Louvain: Institut de Métallurgie. (Price BF.800.)

This theoretical study of quaternary systems is published in two volumes; volume I contains 162 pages of script and an index, and volume II consists of 78 plates of drawings. The work is divided into four main sections. The first part deals with the phase rule and rules governing the contact of phase fields in ternary systems. Although a knowledge of ternary systems is assumed, a few less familiar diagrams are reviewed. These are diagrams showing disappearing eutectic or peritectic lines and diagrams where more than one liquid exists. By a mathematical treatment the author shows the criteria governing eutectic and peritectic transformations and also the transitory stage between the two. This has been introduced to facilitate these conceptions in quaternary systems. In part two attention is paid to orthogonal projections on three projection planes using classical methods of geometry. By this means a fourth dimension (temperature) is introduced by erecting vertical ordinates on a line parallel to one edge of the tetrahedron. This is followed by a repetition of rules governing contact of phase fields in quaternary systems. Part three constitutes the major portion of the work where numerous diagrams are drawn to show the equilibrium states between: (a) a one-phase liquid and one or more solid solutions; (b) a one-phase liquid and one or more intermediate phases; (c) two or more liquids and the solid phases. Orthogonal projections have been used throughout to show the fourth dimension. In part four a general treatment is given to show isothermal and non-isothermal states in a five-component system. Numerous diagrams are produced in half-tone and a great number has been drawn freehand and on much too small a scale. Frequently it was found impossible to check the sections because of the crowding of the lines in the diagrams. In many cases it was not possible to decipher the letters of the various points because of blurring due to the absorbent nature of the paper and also to heavy shading in the half-tone drawings. Examples were found where lettering in the test did not agree with that in the diagram. Figure numbers of some non-isothermal sections were found to be in disagreement with the numbering of the sections in the related projection diagram. Errors of this type indicate that the cross-checking has not been good enough. The binding of the book is poor. Although the method of showing the fourth dimension is interesting there is such a great confusion of so many lines in the diagrams that the reviewer hesitates in recommending this book to a beginner.
—A. J. MACDOUGALL.

GAYDON, A. G., and WOLFHARD, H. G. '*Flames: Their Structure, Radiation, and Temperature*'. 2nd ed. 8½×5½in, pp.xiii+383. Illustrated. 1960, London: Chapman & Hall. (Price £3 10*s*.)

In this second edition of their book on flames the authors have wisely retained the form of the universally acclaimed first edition, carefully revising each chapter, rewriting two, and introducing new material where necessary. The result is a fascinating account of phenomena which were a source of warmth and mystery to the caveman and present intriguing puzzles to his successors. There are chapters on the physical and chemical aspects of stationary flames, on premixed flames, diffusion flames, unstable flames, and flow patterns and flame shapes. A comprehensive account is given of the methods, many being of practical interest, of measuring the fundamental burning velocity of a combustible mixture. The phenomenon of flame propagation is presented together with both the thermal and diffusion theories. Separate chapters are devoted to solid carbon in flames and ionization in flames, fields in which a much fuller understanding is required. While description of radiation from flames occurs in most chapters, an important chapter deals with radiation processes in flames including radiation from solid particles and radiative equilibrium. Two other chapters describe and discuss the various methods of flame temperature measurement and a third outlines the means of calculating the composition and temperature of flames from thermochemical data. The characteristics of unusual combustion processes such as those used in rocket propulsion are discussed in a completely rewritten chapter and a brief note entitled 'Recent Progress in Some Flame Problems' concludes the book.

The authors have not attempted to digest the increasing mass of work in these fields which has accumulated in the past seven years but have discreetly selected the more distinct advances and provided an ample glossary of references which forms a useful guide to the literature. The text is remarkable for its clarity of exposition and is supported throughout by figures and 20 pages of plates comprising 83 individual figures. Two of the plates are in colour and these and the many spectra are the original work of the authors. Though the scope of the book is confined to laboratory flames it provides an insight into the mechanism of combustion processes of value to those engaged in the study of flames of all sizes. It is a 'must' for students and research workers concerned with flame and makes acceptable reading to those with only a passing interest in this everyday subject.—P. J. FOSTER.

GLINER, B. M. '*Determination of the Mechanical and Technological Properties of Metals*'. Translated from the Russian. 2nd ed. 5½×5½in, pp.ix+160. Illustrated. 1960, Oxford, London; Pergamon Press. (Price £2 10*s*.)

The value of many translations from Soviet technical literature is often limited by the extensive use made of symbols and of designations for equipment, unfamiliar to us, by Russian authors. This can be extremely frustrating, but in Gliner's book those interested in mechanical properties and the testing of metals have for the first time a valuable guide to assist in a better understanding of Soviet results and techniques. The book, a translation of a 1959 Soviet second edition, is unusual in construction; an English equivalent would probably result from combining the British Standard Specifications on methods of testing metals with the best of the testing machine manufacturers' technical literature. It is expensive for a fairly short photolitho production, although undoubtedly useful.

In dealing with the many forms of conventional mechanical tests, the author adopts a logical sequence, defining first the properties to be determined, then the method of their calculation; the shape and size of test-pieces used, followed by a description of the relevant Soviet testing equipment with the help of schematic diagrams. That 30 of the 160 pages should be devoted to room temperature tensile testing is unfortunate, since it means that only brief mention can then be made of other tests of equal interest. Fatigue for instance is dealt with in a mere six pages, only the rotating beam type test is discussed. A fuller description of other tests in common use in the Soviet Union such as the hot hardness test and creep tests of ring-shaped test-pieces would have been appreciated. Of the properties defined as technological the book deals briefly with the determination of machineability, hardenability, weldability, and also describes a range of tests on tubes which though known here are regarded as empirical and not covered by Standards.—J. CLAYTON-CAVE.

THE INSTITUTION OF MINING AND METALLURGY. '*International Mineral Processing Congress*, 1960'. 8½×5½in, pp.xiii+1118. Illustrated. 1960, London: The Institution. (Price £5.)

A number of mineral processing conferences have been held in various European countries within the last eight years. These have attracted papers from all over the world and have proved a valuable occasion for bringing the newest developments to all those interested in this field. The proceedings of the latest conference held in London in April 1960 and arranged by The Institution of Mining and Metallurgy have been collected together with both spoken and written contributions to the discussion. Technical sessions were held under nine headings, viz. comminution; classification and thickening; flotation research; flotation practice; gravity and dense media separation; magnetic and electrical separation; chemical processing; process study; control and testing. A number of papers were concerned with the concentration of iron ores. The Aerofall mill has been under development for a number of years; its application to magnetite ores and performance comparisons made with rod-mills was discussed in a paper from Sweden. Considerable saving in costs is claimed. A useful survey of new developments in the magnetic concentration of iron ores was given by F. D. De Vaney, while further work, again from Sweden, on magnetic roasting was described by S. Eketorp. Classification and thickening tended to be dominated by studies on cyclones.

The increasing exploitation of complex ores, e.g. uranium, has led to the development of chemical processing in cases where physical methods are not applicable. Five papers on this subject emphasize that this is becoming an increasingly important aspect of mineral processing. A significant contribution was given in a paper on automatic control in mineral processing; this subject can be expected to attract a great deal of development in the future. This very considerable reference book is supported by numerous figures and tables as well as subject and author indexes.—G. E. DAVIES.

JONES, W. D. '*Fundamental Principles of Powder Metallurgy*'. 8½×5½in, pp.xii+1032. Illustrated. 1960, London: Edward Arnold (Publishers) Ltd. (Price £7 7*s*.)

Prior to the last war, except in specialized fields such as the lamp industry, powder metallurgy was developing only slowly from an art to a technology. In more recent times, however, there has been a marked increase in basic and applied research studies with an accompanying expansion in production and application. In 1937, Dr Jones in '*Principles of Powder Metallurgy*', purveyed what little

was then known of the science. It is significant that some 25 years later he introduces the work 'fundamental' into the title and requires nearly 1000 pages of text with 316 illustrations to deal comprehensively and critically with the basic principles of the subject.

Almost one-quarter of the book deals with the manufacture of metal powders under the primary headings of chemical reactions or decompositions, electrolysis, mechanical processing, and atomization. Each of these sections is introduced with an account of the theoretical principles involved, followed by descriptions of processes, often as applied to a wide variety of metals, and the effects of processing variables on powder characteristics and process efficiency. In the chapter on pressing, the reader is first introduced to frictional and adhesional forces, and is led systematically to analyse the sequence of events in the packing of powders, and the effects of external pressure, die friction, and lubrication. The principles of the design of presses and dies are discussed, and the less common methods of compaction including hot pressing, isostatic pressing, and explosive pressing are described. Shaping without pressure is dealt with in a short chapter which appeals for a considerable increase in the investigation of processes based on this principle. The two following chapters which deal respectively with sintering and with the attainment of specific qualities take up more than half the book. The possible sintering mechanisms are discussed at length and the various sintering theories are fully reviewed. Sintering in polyphase systems (including non-metallic compounds), infiltration and liquid-phase sintering are adequately described. The sections of this chapter dealing with chemical reactions during sintering, and with sintering furnaces and atmospheres, provide information which will be of great value both to the student and the practising powder metallurgist. The attainment of specific qualities in the sintered product is, in every case, discussed with respect to the basic principles which influence the particular property, and the extent to which such qualities are realized in sintered products. The section on magnetic materials requires special mention, since apart from sintered alloys it includes extensive treatment of the preparation and properties of ferrites and dust cores. The final 100 pages of this chapter are unique, in that they consider the competitive processes of powder metallurgy from the standpoint of manufacturing costs and profit margings. The chapter on continuous powder metallurgy, while deploring the slow rate of progress, brings the book right up-to-date with the present stage of development in an area which the author undoubtedly believes holds the key to the future of the industry. The final chapter provides a concise but adequate account of methods of control.

The book is well written, is authoritative and critical, and in spite of the surfeit of publications in this field there can be no doubt that it will be warmly welcomed, not only by those directly concerned with the subject but also by those who may wish to have a clear presentation of the theoretical and practical principles involved. There are extensive references, and there can be little that the author has omitted. Indeed, there may be some who will feel that he has often stepped too far outside his legitimate territory and introduced material not strictly relevant to the subject, but if there are such critics they should bear in mind that the book has been written both as a textbook for the student and as a treatise for the more mature reader. The quality of reproduction is excellent and the book undoubtedly will be accepted as a standard work of reference for many years to come.—I. Jenkins.

Livshits, A. L. '*Electro-Erosion Machining of Metals*'. Translated from the Russian by E. Bishop. 9 × 5¼in, pp.xi + 115. Illustrated. 1960, London: Butterworths. (Price £1 10s.)

Published in association with the Department of Scientific and Industrial Research, this translation of a Russian work which appeared in 1957, is a valuable addition to the literature on electroerosion machining, a branch of 'electrotechnology' described in the introduction as still 'in the early stages of development.'

A fairly comprehensive description of the electrical circuits of Russian machines is given, but it would have been more useful if the electrical symbols employed in these circuits had been re-drawn to British Standards. Bearing in mind that this book will be read by mechanical engineers they are liable to be confused when they see a symbol which looks like a resistor used to denote a transformer. Also it is normal in electrical formulae to denote electromotive forces by 'E' or 'e' and voltages by 'V' or 'v'. The translator has however decided to use the Russian symbols, which, as most of the book is devoted to electrical circuitry, has made it difficult to follow.

Apart from these small points, the book gives information relating to electroerosion machines which has not been published before in this country.—G. D. Shingler.

Ress, F. M. '*Bauten, Denkmäler und Stiftungen deutscher Eisenhüttenleute*'. 11 × 9½in, pp.xxxviii + 319. Illustrated. 1960, Düsseldorf: Verlag Stahleisen. (Price DM.90.—.)

This most attractive and interesting book was published by the Verein Deutscher Eisenhüttenleute on the occasion of their centenary in 1960 to commemmorate the ancient German iron industry. The author has carefully selected illustrations to demonstrate the evolution of German ironmaking from about AD.1300 to 1850 with its ramifications in industrial, social, and cultural life. Portraits of some of the leading individuals and their families are provided, the exteriors of ancient buildings are reproduced and there are also valuable plans and drawings affording insight into the interior and equipment of forges and furnaces. The excellent reproductions, frequently many-coloured, are taken from the originals and from evidence preserved principally in South German archives, such as Amberg (which may rightly be called the Ruhr of the German Middle Ages), Munich, Regensburg, Sulzbach, and Stuttgart. Of special interest is the introduction in which the author gives a résumé of the historical development; he also suggests that the present book will be followed by an illustrated history of the whole German iron and steel industry to which we are eagerly looking forward.

—H. R. Schubert.

The Society for Nondestructive Testing. '*Symposium on the Nondestructive Testing of Stainless Steel Brazed Honeycomb Structures*'. 9 × 6in, pp.xii + 281. Illustrated. 1960, Chicago: The Society. (Price $25.00.)

This volume contains some 22 papers, discussion, and summing-up, presented at a three-day Symposium in Chicago in July 1959. Anyone concerned with non-destructive testing will find it stimulating and worth while reading.

Honeycombs essentially consist of two thin parallel sheets, spaced apart by a cellular array of corrugated foil. The bending and compression strength-to-weight ratio of such panels can exceed that of comparable solid panels by several powers of ten; this accounts for their great importance to aircraft and missile development. It is not surprizing to find that the amount of thought devoted to the nondestructive testing of these complex, fabricated, load-bearing structures is quite formidable. The first five papers outline service and design requirements, manufacturing problems, and other broad aspects. The sixth paper (W. A. Mays) contains a critical survey of the relevant characteristics and applicable test methods, i.e. thermal conductivity, ultrasonic, and X-ray techniques; equipment and tests used by North American Aviation Inc., are described and illustrated. John E. Jacobs of G.E. Co. gives a comprehensive account of TVX-systems using X-rays, image intensifiers, converters, X-icon, and closed-circuit television in various combinations. In subsequent papers, we learn about high-definition fluoroscopy (Westinghouse), the Norelco image intensifier (Philips), photofluorography (Picker), xeroradiography (G.E. Co.), the ultrasonic reflectoscope (Sperry), ultrasonic 'C' scan recorded on 'dry electrosensitive paper' (Curtiss-Wright), 'Coinda-scope' swept frequency ultrasonic and 'Hot Shot Tester' thermal stressing instruments (Almar-York Inc.), thermographic methods (Magnaflux Corp.), and heat-sensitive paint inspection (Curtiss-Wright). Reproduction of the full, unedited (?) discussions has a sobering effect and adds an element of down-to-earth reality. The 'Summary' at the end by Robert S. C. McMaster will serve the reader as an excellent introduction.

Most papers are well illustrated, showing test equipment as well as displays, records, and photographs of specimens or defects. The total absence of Bibliography references is regrettable particularly because the reports and papers are kept fairly general.

—G. Syke.

Tallmann, H. '*Was der Hochöfner von seiner Arbeit wissen muss*'. Tolksdorf, A. '*Was der Kronführer von seiner Arbeit wissen muss*'. 8½ × 5½in, Stahleisen-Schriften Heft 5, Heft 1. pp.201, 126. Illustrated. 1960, 1961, Düsseldorf: Verlag Stahleisen mbH. (Price DM.13.80; DM.7.80.)

Here are two well-prepared text-books for operatives, which make liberal use of clear diagrams and photographs.

The first, which deals with the job of the blast-furnace operative, contains much useful background information on other steelworks processes and the historical development of iron production, and deals comprehensively with all aspects of blast-furnace practice. Fuels, refractories, ores and their preparation, fluxes and other additions, furnace operation and irregularities, furnace construction, burdening, ancillary equipment, and manning are all treated in a simple, practical manner. Chemical reactions are also explained simply but effectively and an appendix in which basic principles of chemistry are outlined supplements this section of the book.

The second book, written for the steelworks crane driver, follows a similar pattern. A historical review of crane development is followed by chapters dealing with steelworks cranes, their construction, mechanical and electrical equipment, and controls and the effects and dangers of abusing them. A chapter on crane driving is included and it is encouraging that prominence is given to slinging practice and lifting tackle.

In both books the safety aspect is sensibly stressed and each contains a separate section devoted to rules for accident prevention. The books achieve admirably what they set out to do—to provide the operative with what he needs to know about the plant and equipment surrounding his job. Neither book presupposes any previous knowledge or experience. In both the subject is covered very completely and in simple and readily understandable terms, although in the attempt to simplify explanations the text occasionally tends towards prolixity. As aids to operative training—a field of training which seldom receives the attention which is its due—both books are of considerable value. They provide useful models for further work in this field.—J. Baker.

Verein Deutscher Eisenhüttenleute. Chemikerausschuss. '*Handbuch für das Eisenhüttenlaboratorium*'. Band I. Die Untersuchung der Nichtmetallischen Stoffe. 2 Auflage. 10 × 7in, pp.xviii + 322. Illustrated. 1960, Düsseldorf: Verlag Stahleisen. (Price DM.43.—.)

This excellent handbook prepared by the Verein Deutscher Eisenhüttenleute for the use of steelworks laboratories deals with the analysis and testing of practically all the non-metallic materials that are used in the iron and steel industry. It is divided into 12 sections dealing with ores, rock phosphate, fluxing agents, flue dust, cements, ceramics, solid fuels, gases, coke-oven by-products, fuel oils, and lubricants, transformer oils,

and water respectively. More than 20 well-known German experts have collaborated in the preparation of the book and the chemical, physical, and physico-chemical methods that are so precisely described have been tested exhaustively by German industry. From an Englishman's point of view it is perhaps a little unfortunate that the book is in German but it is so simply worded and the layout is so good that anyone with only an elementary knowledge of the language will have no difficulty in following it. The index is adequate but there is no bibliography and none is needed, as the book is intended to be, and is, self-contained.

The back-referencing system used throughout is particularly effective. When reference is made to a previously described standard solution, method, or the like, the page number is followed by a symbol. When one turns to the referred-to page the same symbol printed in the margin indicates the exact location of the reference. In this publication five symbols suffice, viz. a circle, rectangle, square, triangle, and diamond. The book has a pleasing and durable binding and is clearly printed on good paper.—J. F. KAYSER.

WUSATOWSKI, Z. '*Podstawy Walcowania*' [Fundamentals of Rolling]. In Polish. 9½ × 6½in, pp.471. Illustrated. 1960, Katowice: Wydawnictwo Górniczo-Hutnicze. (Price Zł.85.00.)

Although rolling-mill engineers in Western countries are already amply provided with good text-books on the fundamentals of rolling, notably in the English language, they can ill afford to ignore Prof. Wusatowski's book, notwithstanding linguistic difficulties.

The book deserves special notice in the West, for two reasons. Firstly, it contains up-to-date and comprehensive information on the author's own distinguished researches in which he is laying the foundations of a scientific treatment of the hot rolling of flats and shapes, and this includes experimental data, at present unique, of spread, slip, and forces in the rolling of steel semis. Secondly, the author, being equally at home with Russian as well as with Western literature on the mechanics of rolling, has made a critical comparison of the two, which is particularly helpful to Western students to whom Russian work is virtually unknown and who, by the chance perusal of inferior papers, might be discouraged from a study of it.

The book is in six parts, comprising 35 chapters. Parts one and two, which cover the phenomenology and mathematics of metal plasticity, are inferior to comparable English texts; the Western reader can well afford to skip these two parts. Parts three and four are devoted to the theory of rolling and are generally of a high standard. Chapters 15–20 of the third part deserve the reader's special attention, as they contain most of the new material on rolling with free and constrained spread, which is not to be found in any books in the English language. Part five is devoted to the stressing of rolls and mills, and to the measurement of the parameters of rolling mechanics on laboratory and production mills. Part six deals with the principles of pass design and although, inevitably, it goes over familiar ground of several standard works in English and German, the analytical treatment of the subject is pushed further by the author and problems such as pass design for continuous rolling mills are included for the first time.

Throughout the book, the author has had the practical engineer very much in mind. Each chapter abounds in worked examples and the use of the many involved formulae is simplified by ample provision of nomograms, usable graphs, and tables. The work as a whole is enhanced by numerous instances of a critical comparison of alternative methods of analysis and calculation, backed by the acid test of experimental evidence drawn from well-documented literature.

As this is the first edition of the book, it is perhaps inevitable, considering its type and range, that a number of errors and misprints have survived the proof reading. The most important of these have been corrected by the author in a note added after printing and the remainder are to be dealt with in German and Russian translations of the book, which are scheduled for publication in Leipzig and Moscow.

Summing up, this is an important book for rolling mill engineers, and although only a few of them in this country will be able to derive full benefit from it until it is translated into English, those familiar with the subject should not find it too difficult a task to acquire a working knowledge of the legends of the most important graphs relating to spread and slip in hot rolling and to pass design, contained in Figs.61–83, 111–118, 130–132, 313–318, together with the associated tables.—J. G. WISTREICH.

NEW PUBLICATIONS

These titles are also available on index cards in advance of publication in the Journal, *each title being classified under the Universal Decimal system (UDC). Details and subscription rates can be obtained from the Secretary, The Iron and Steel Institute.*

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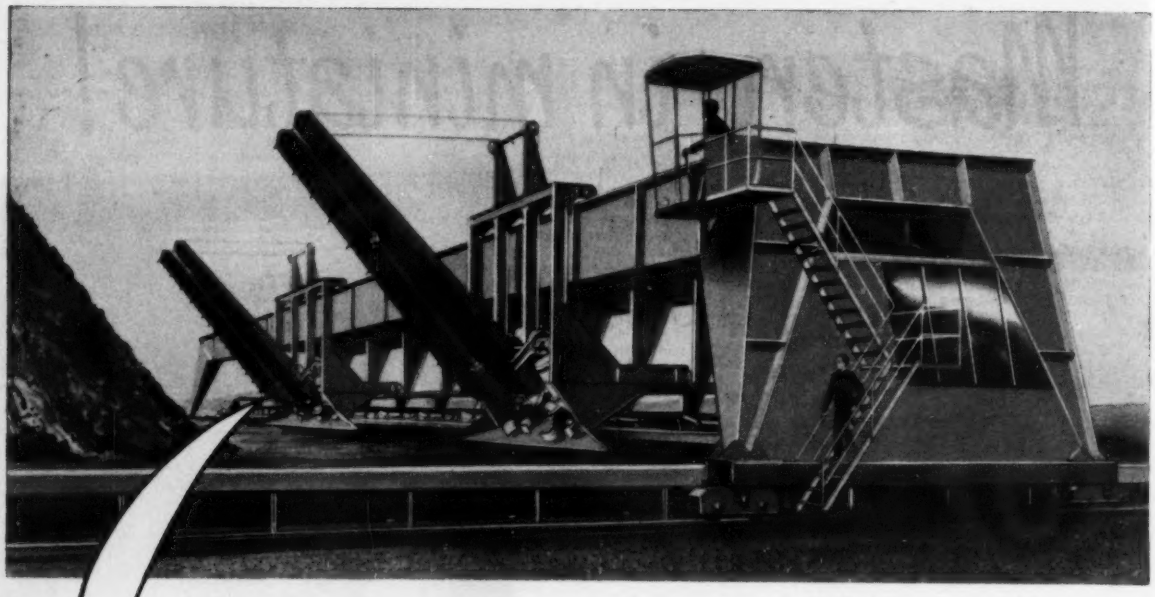

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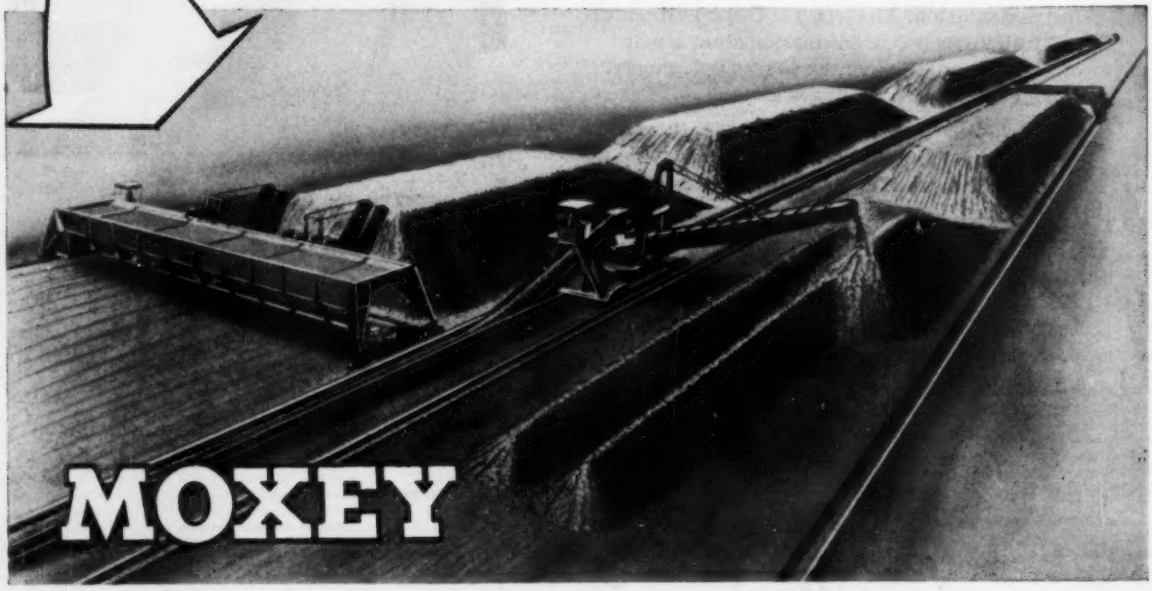

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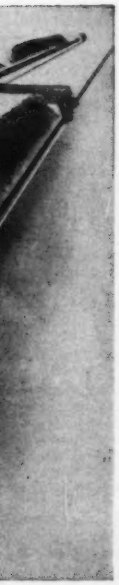

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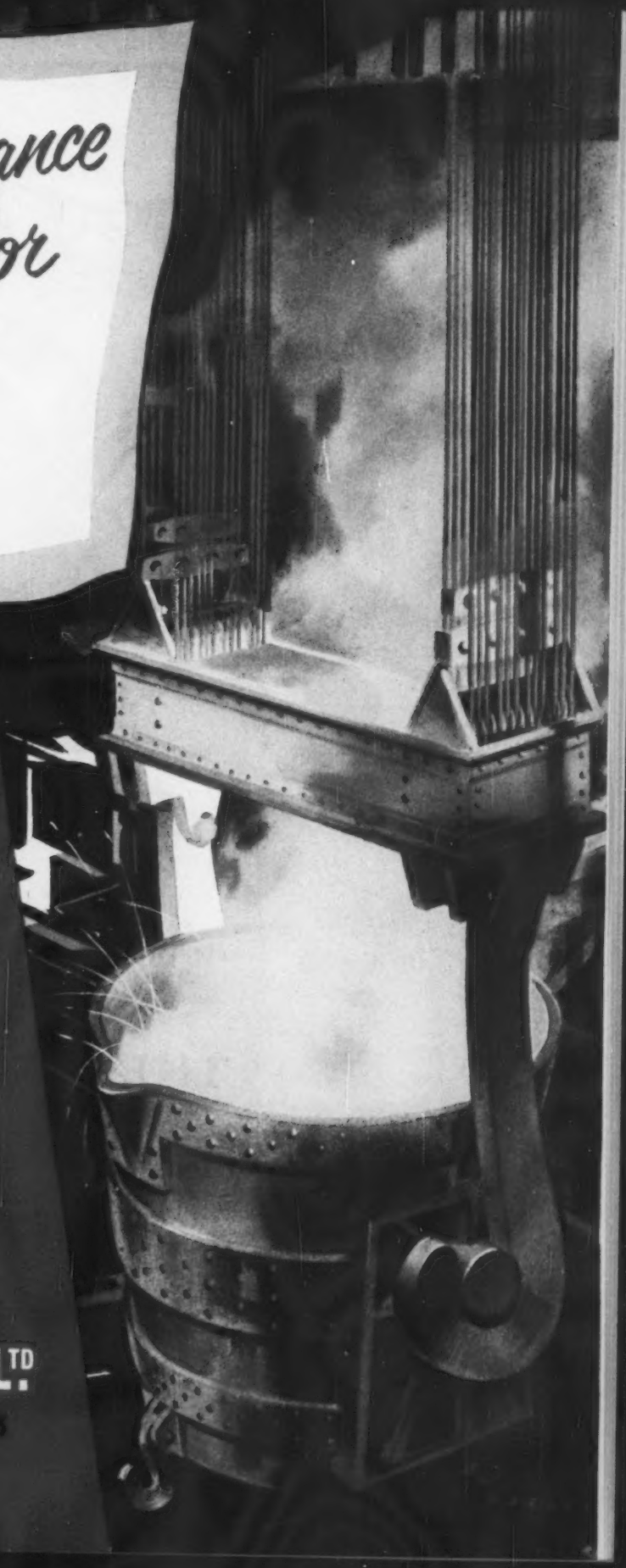

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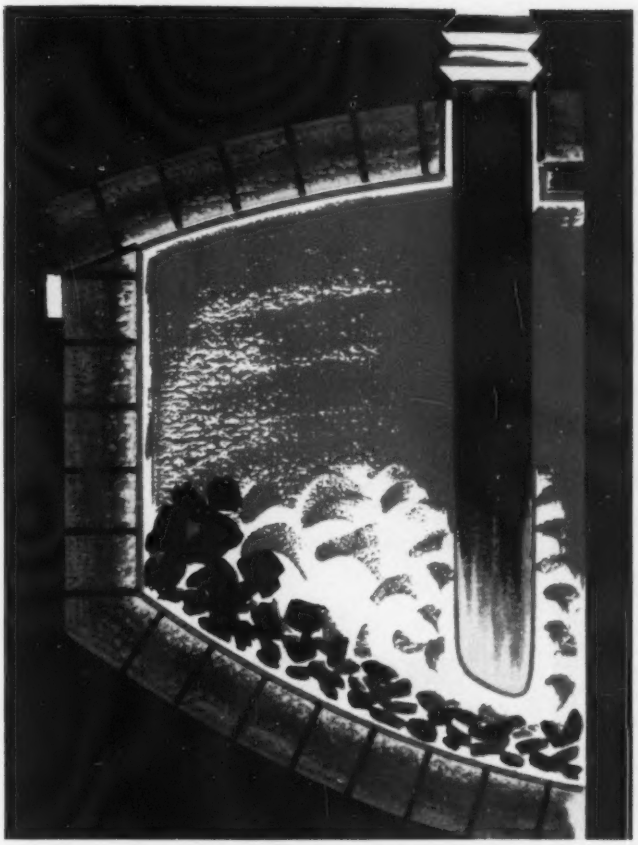

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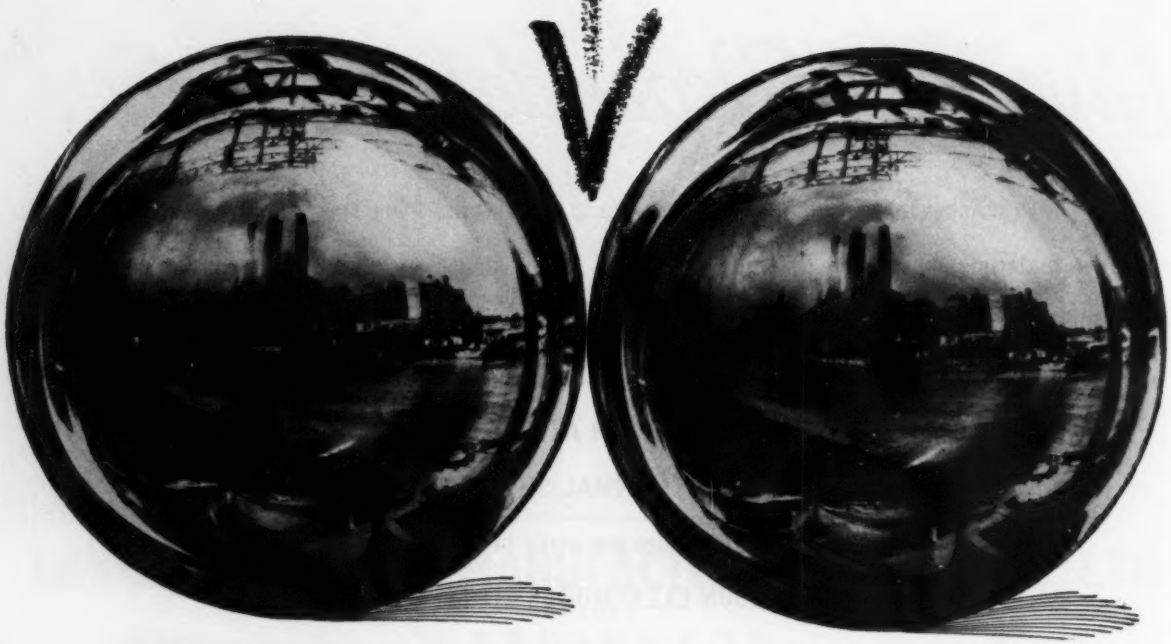

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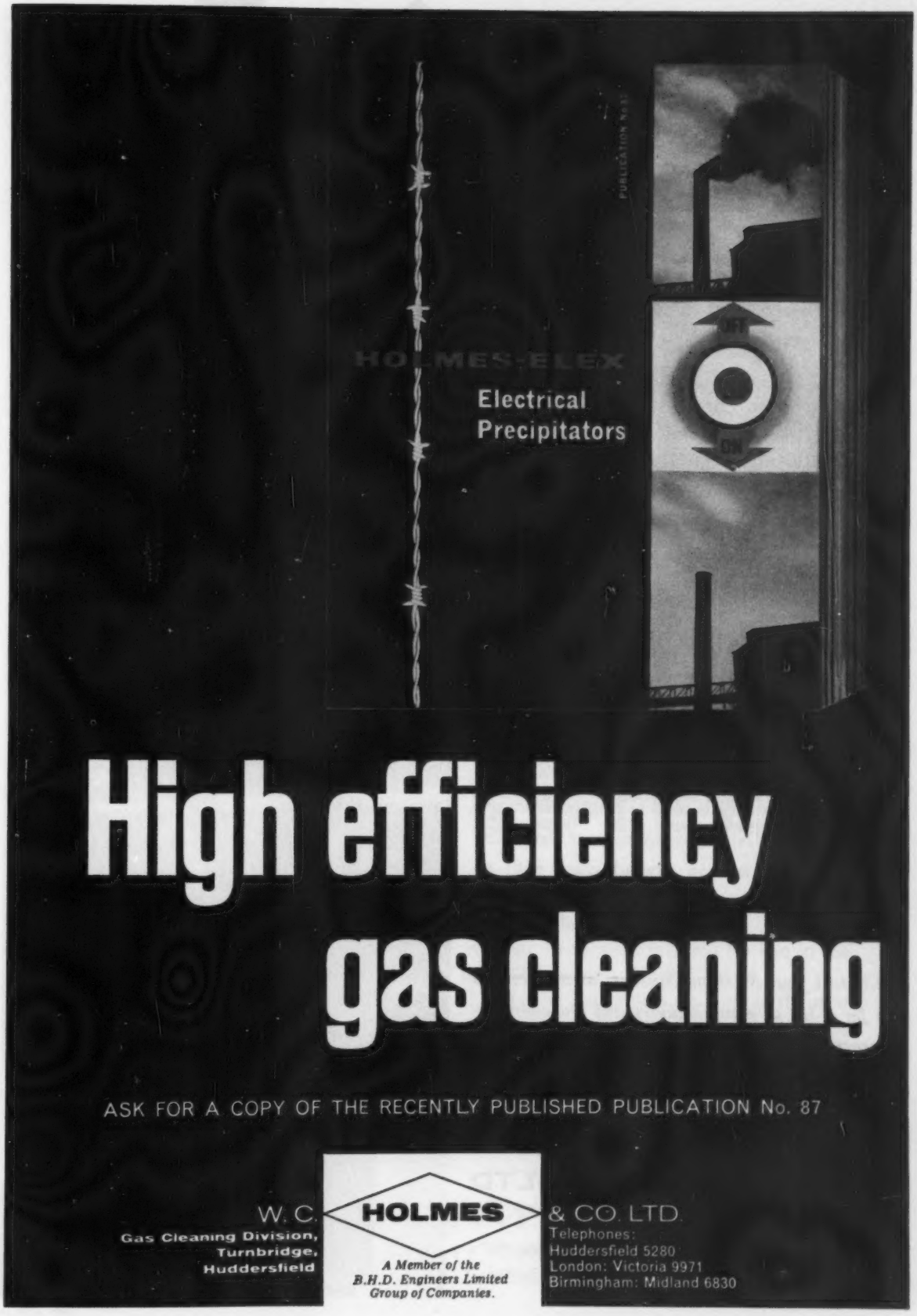

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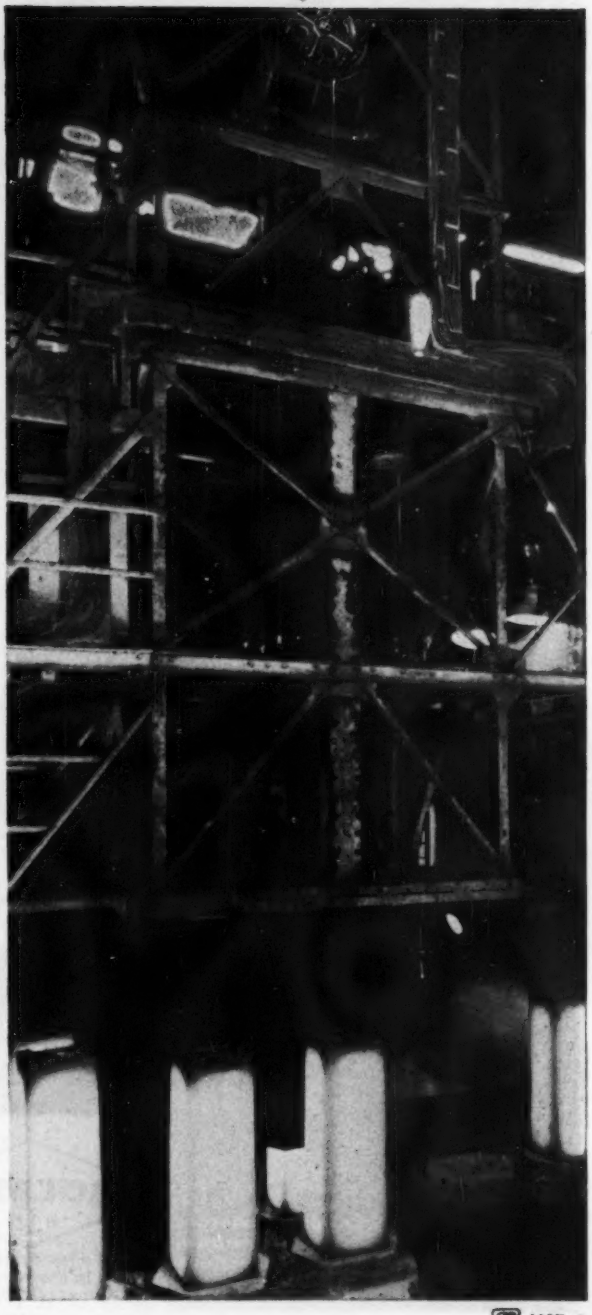

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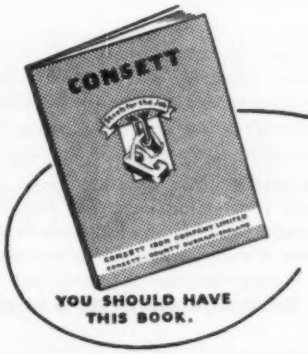

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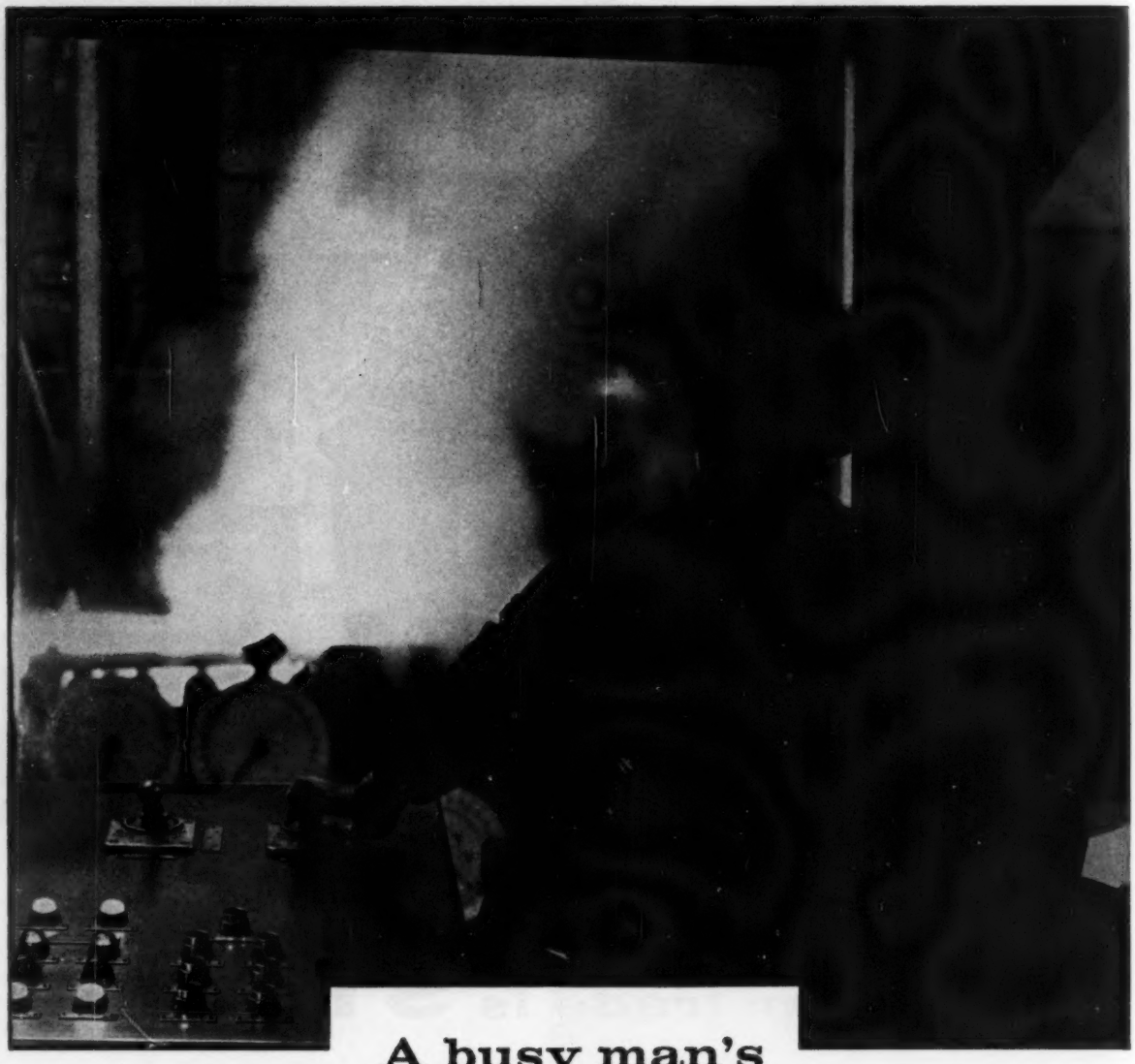


A busy man's guide to Britain's steel progress

WINSTON CHURCHILL kept his finger on the pulse of things by asking for important information "on one side of a sheet of paper".

The post-war achievements of the British steel industry would fill a book. Here, for the busy man whose eye we have this minute, is an account of what is happening now.

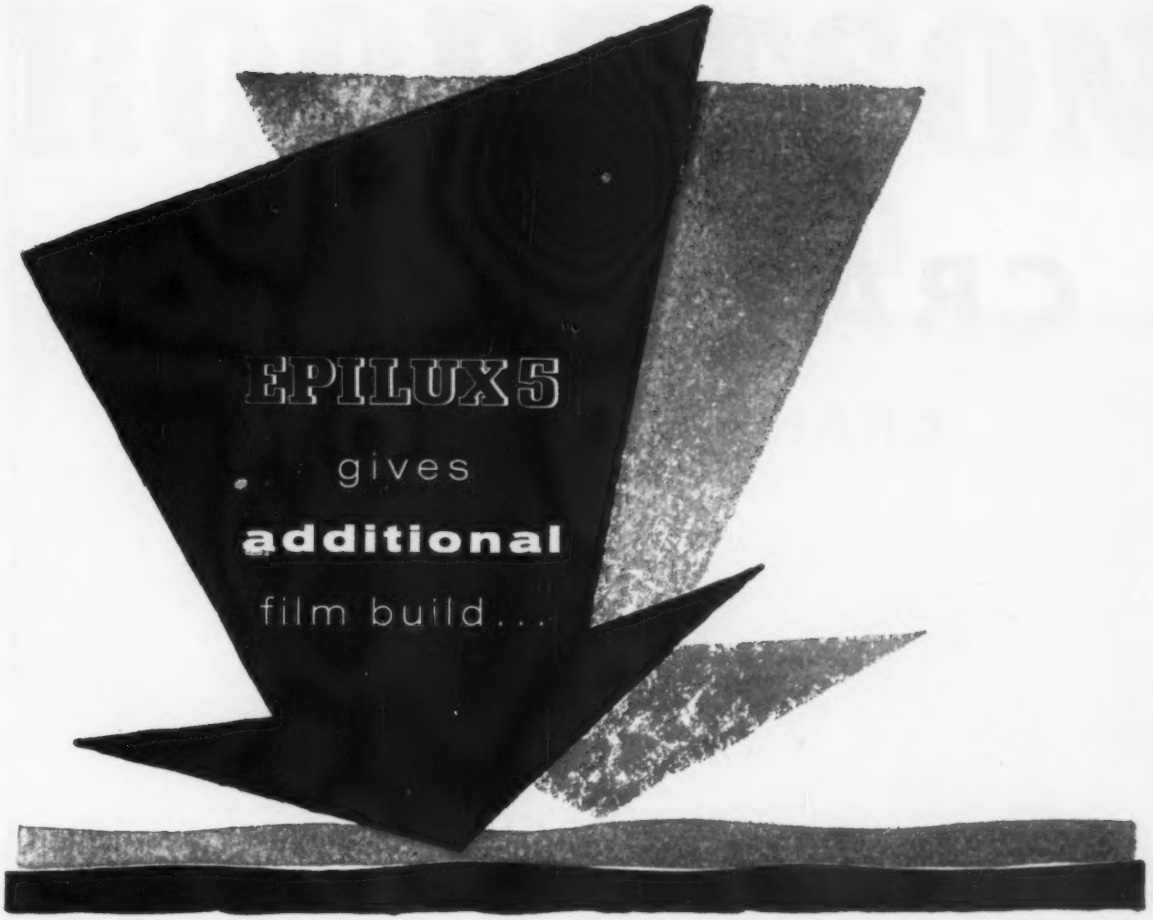
PRODUCTION The British steel industry produced over 24 million tons of steel in 1960 – compared with 20 million tons in 1959. Output is now about *double* the pre-war figure. Production of alloy steels – especially stainless steel – is expanding particularly rapidly.

PLANT Since the end of 1946, over £900,000,000 has been spent on development. Continued modernisation and expansion – now costing some £200,000,000 a year – will provide steel capacity for over 34 million tons by 1965. Pig iron output per furnace and open hearth steel output per furnace are both more than double pre-war. With the need for ever-increasing efficiency and economy, ore beneficiation has made great strides and fuel consumption per ton of iron has been reduced by about 25% since the war. Use of oxygen for steelmaking is rapidly increasing.

INDUSTRIAL RELATIONS The industry keeps its remarkably good record for settling industrial disputes without recourse to strike action. British steel workers are often sons and grandsons of steel workers, richly endowed with traditional skills. Making steel exactly to specification is more than a commercial requirement; it's a matter of pride.

PRICES British steel prices have been keenly competitive since the war with those of other major European producers and well below the American price level – and the quality of British steel is unsurpassed.

BRITISH IRON AND STEEL FEDERATION



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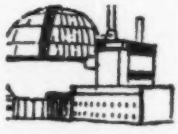

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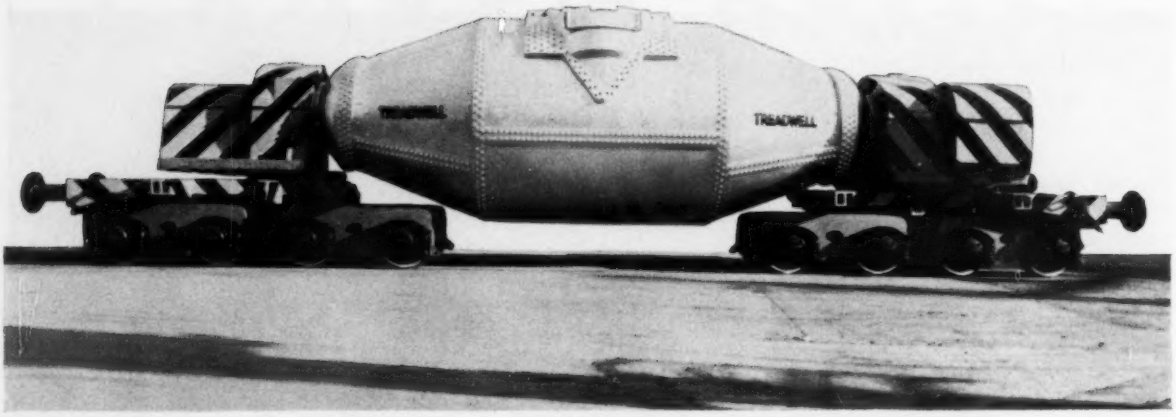

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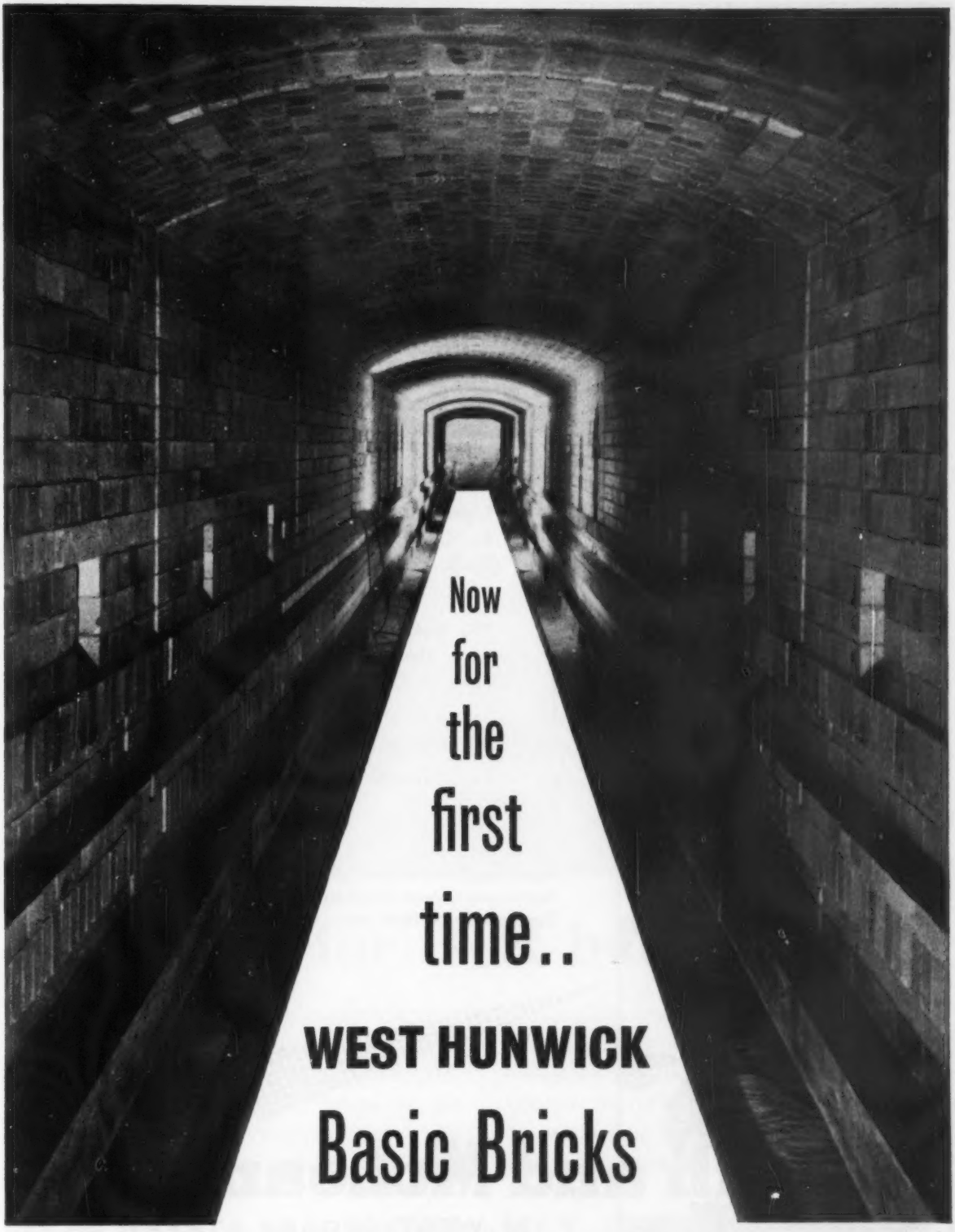

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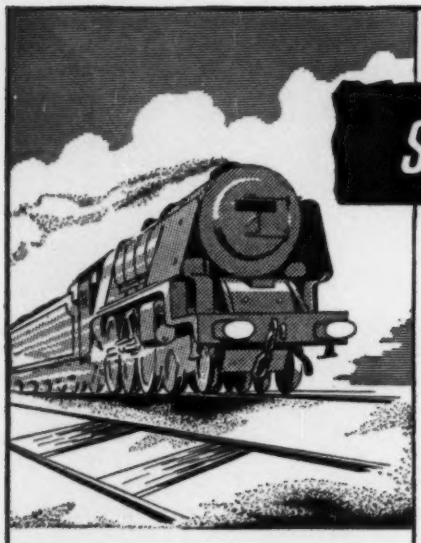

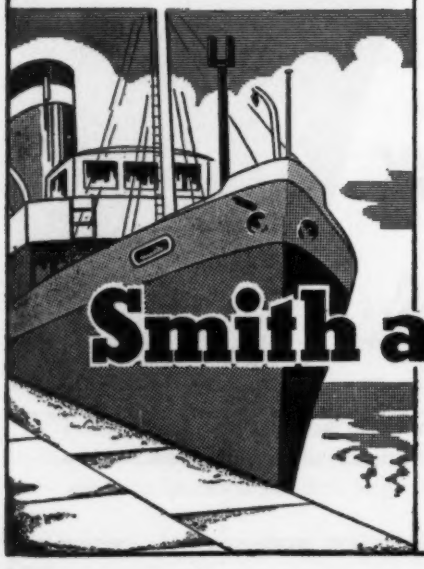

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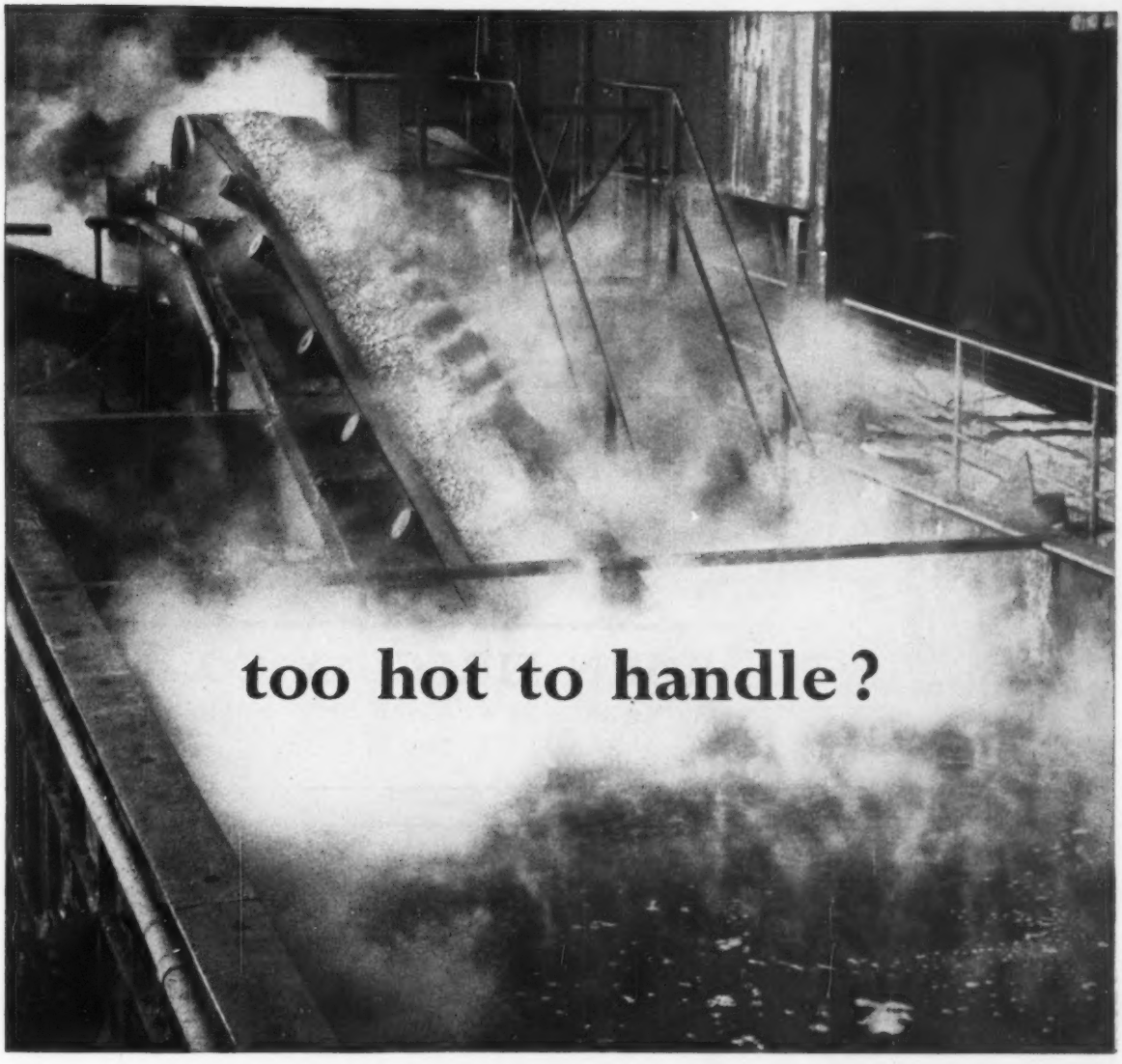

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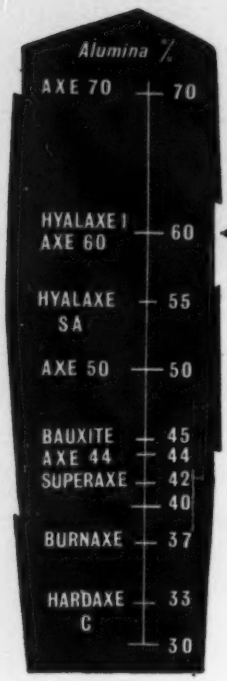

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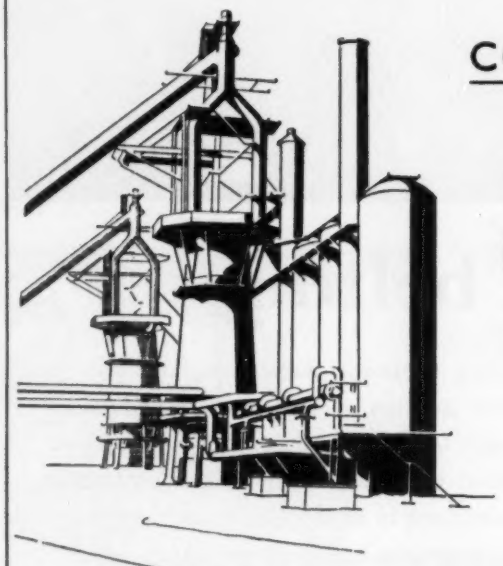

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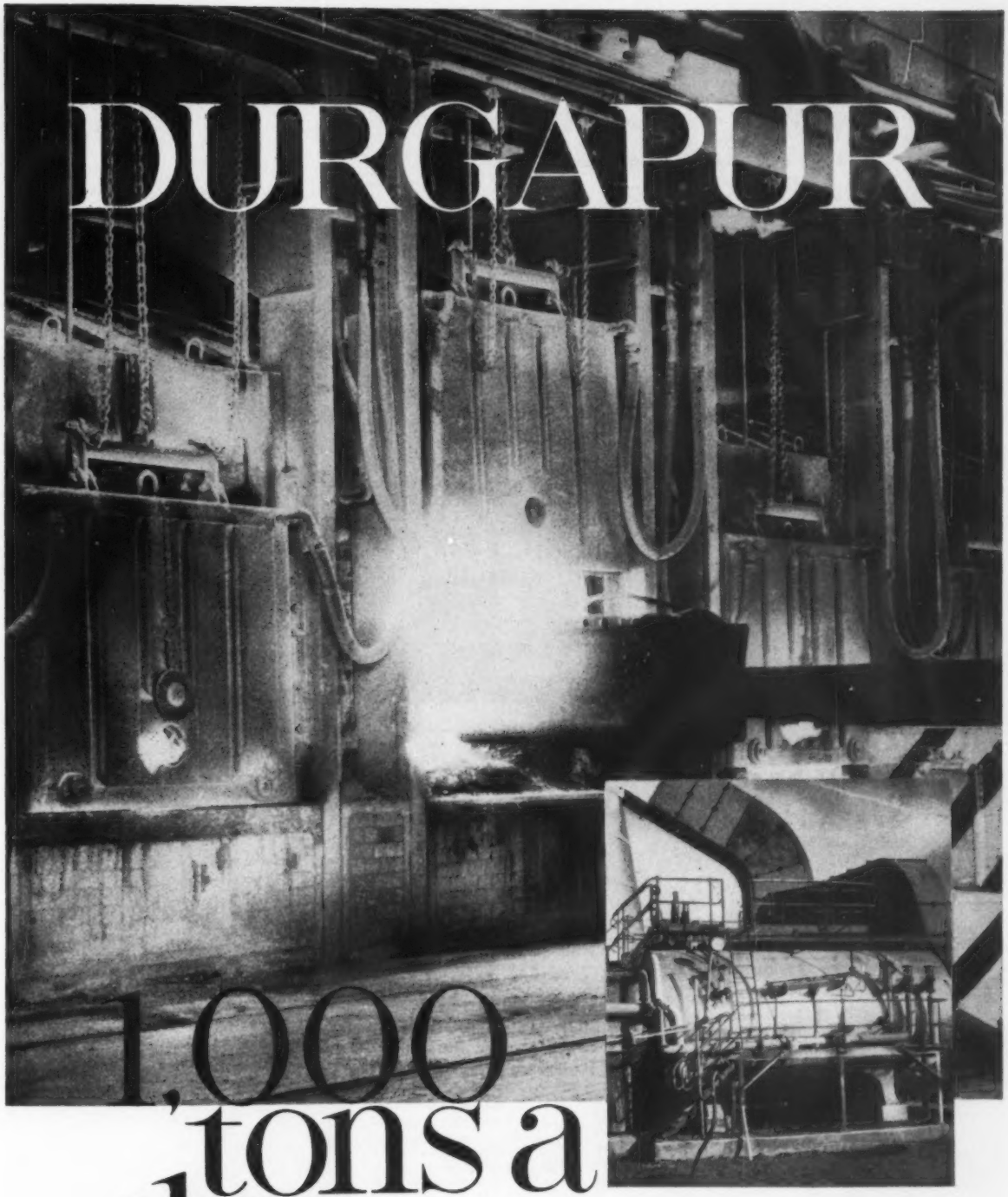

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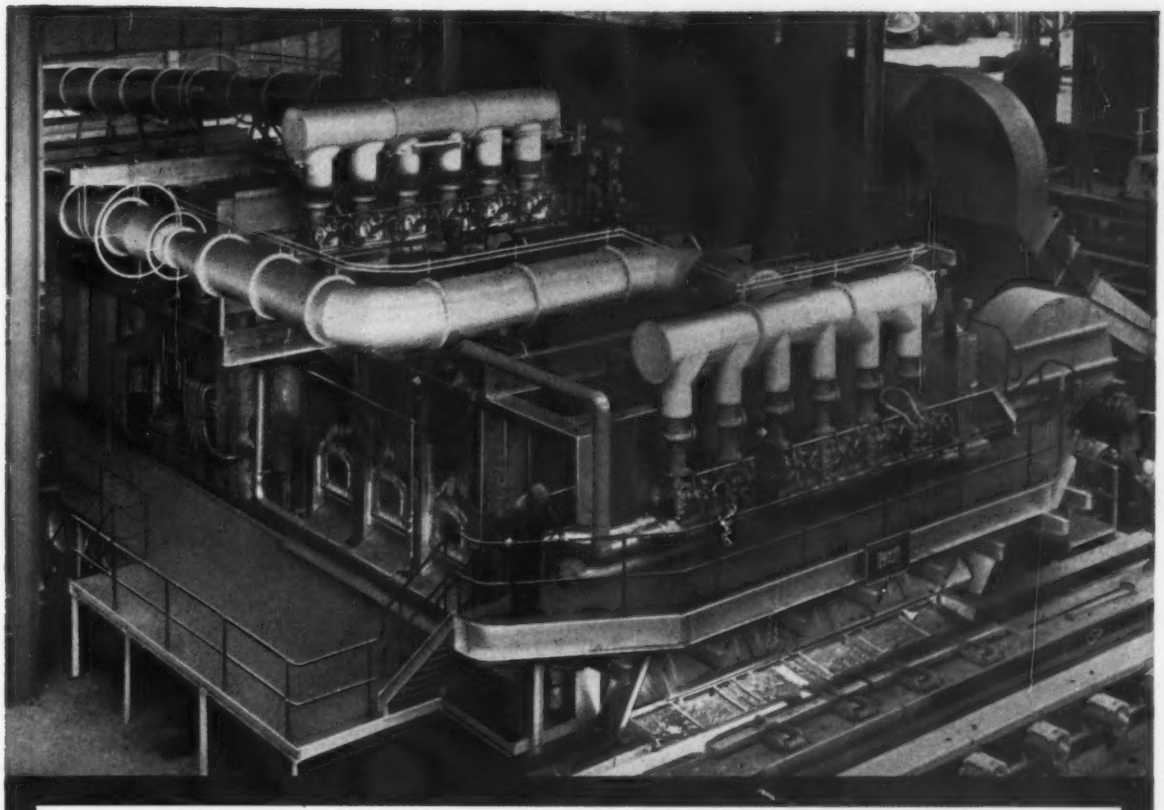

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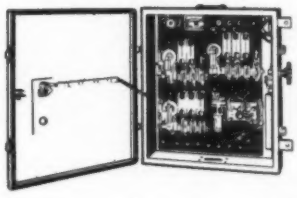

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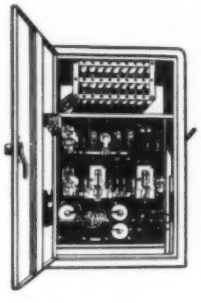

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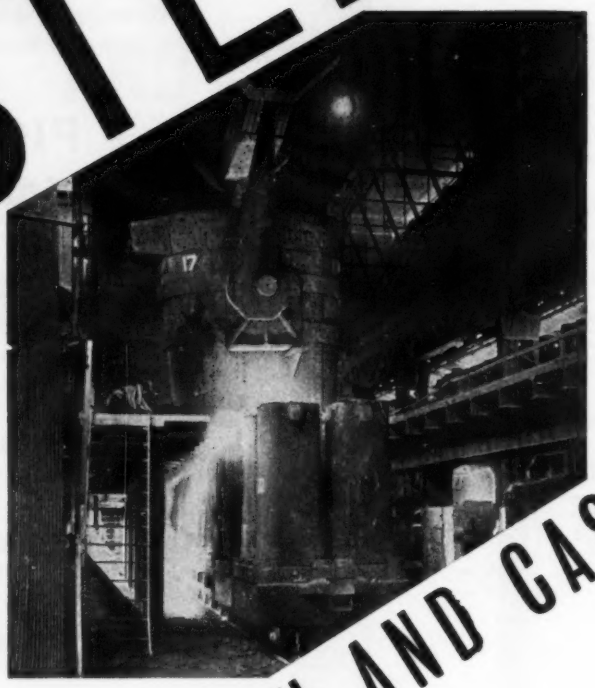

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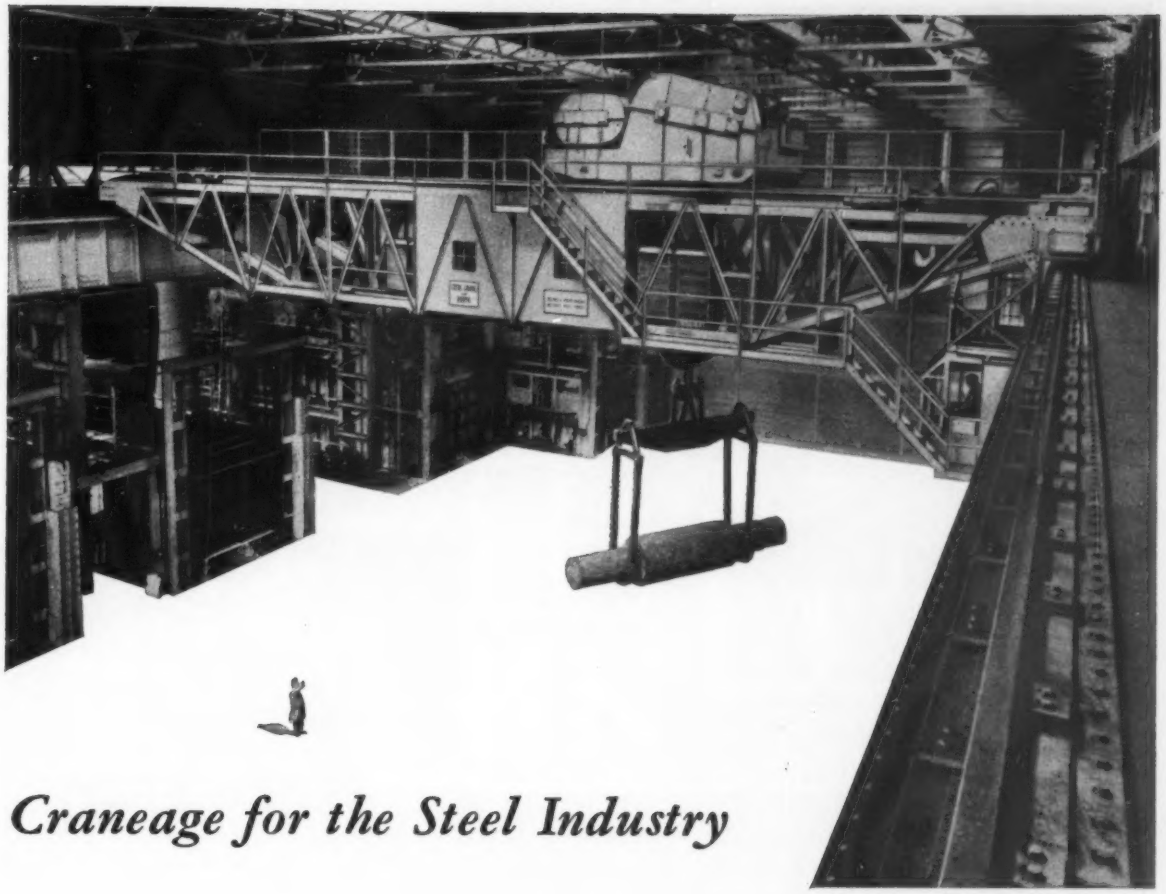

Craneage for the Steel Industry

Upper photograph by courtesy of Messrs. Thomas Firth & John Brown Ltd.

A 130/40 tons heavy duty electric overhead travelling crane handling forgings in the Bessemer Heat Treatment Department at Messrs. Thos. Firth & John Brown Ltd., Sheffield.

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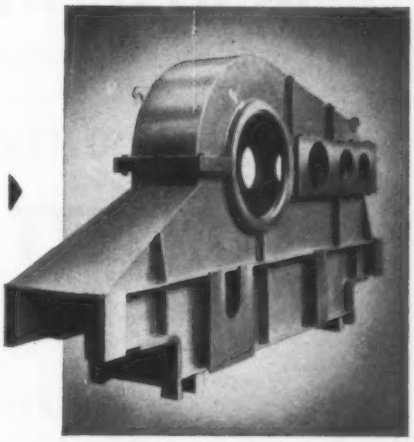

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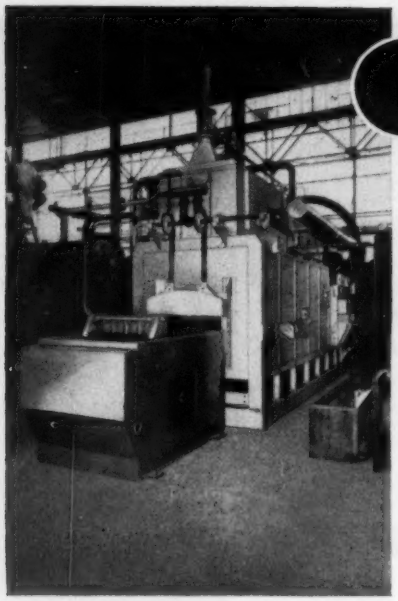

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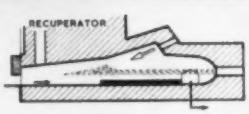

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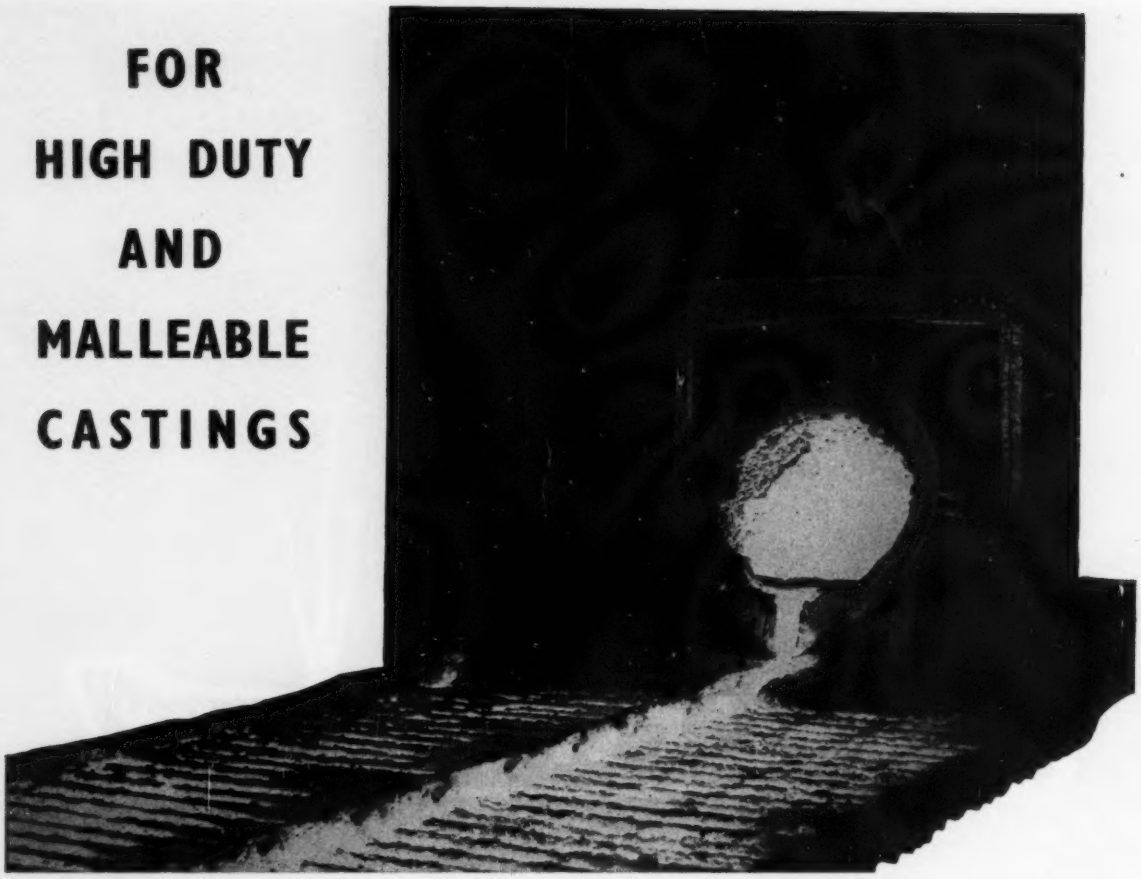

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GRADES:	A	B	C	D	E	F	G
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SULPHUR%	0·06	0·07	0·08	0·05	0·08	0·07	0·06
PHOSPHORUS%	0·6–0·7	0·6–0·7	0·6–0·7	0·4–0·5	0·25	0·25	0·25
MANGANESE%	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5
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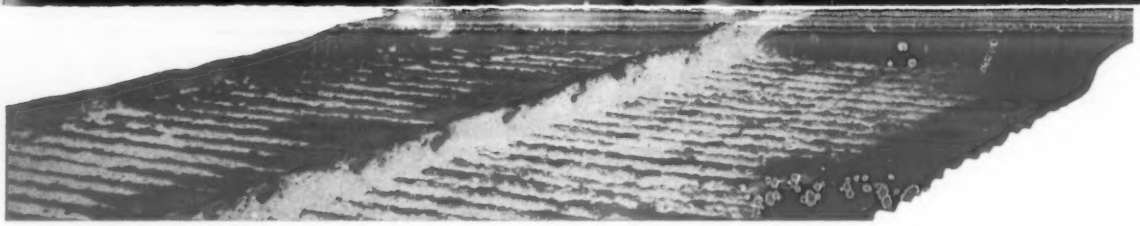

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PHOSPHORUS%	0·6–0·7	0·6–0·7	0·6–0·7	0·4–0·5	0·25	0·25	0·25
MANGANESE%	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5	0·8–1·5
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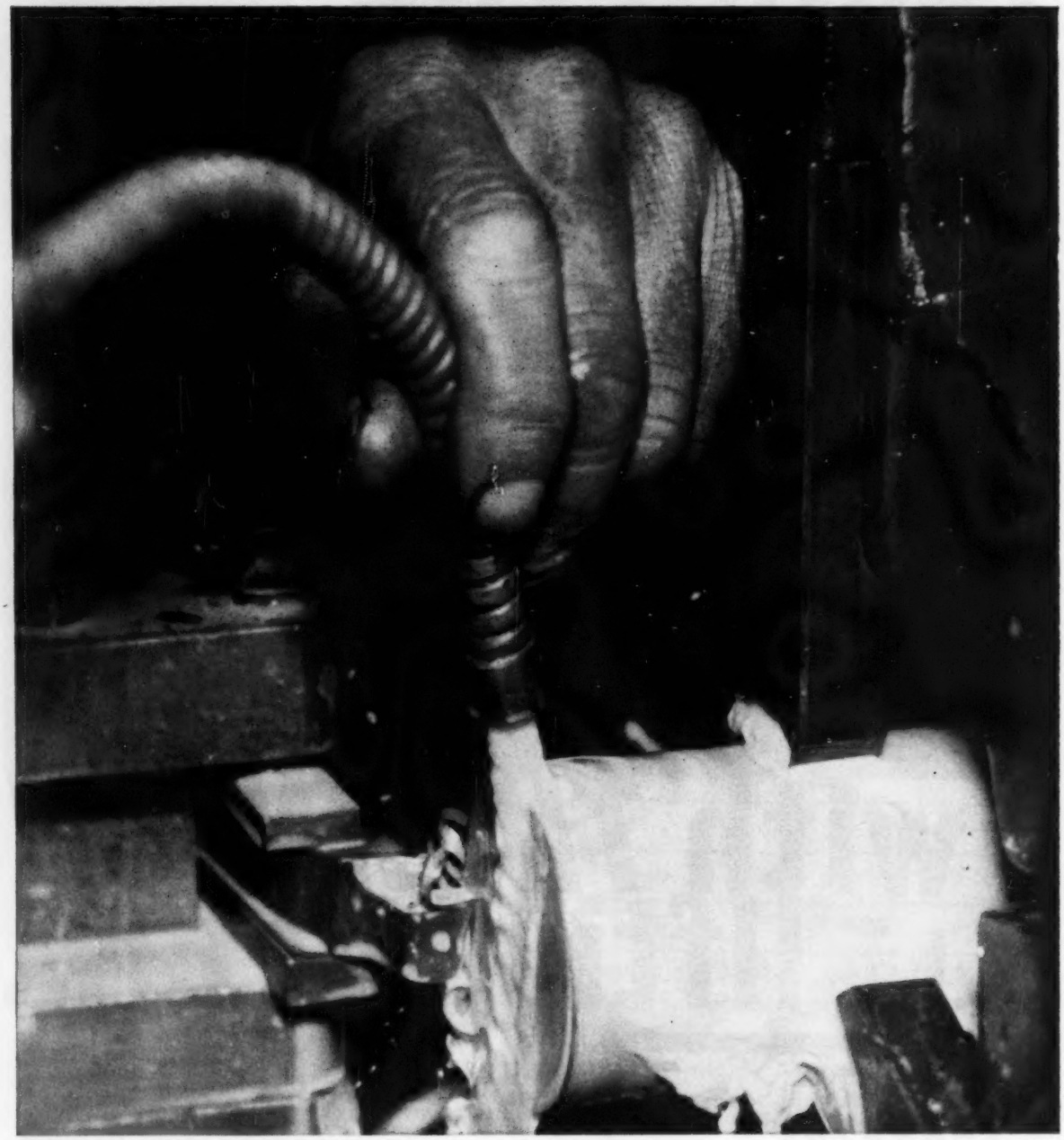

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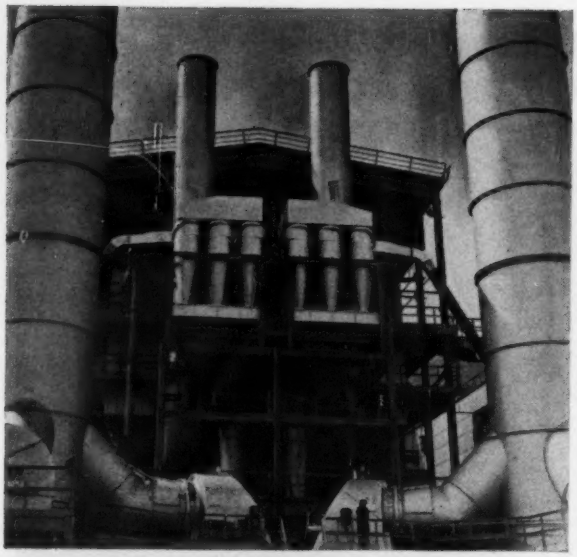

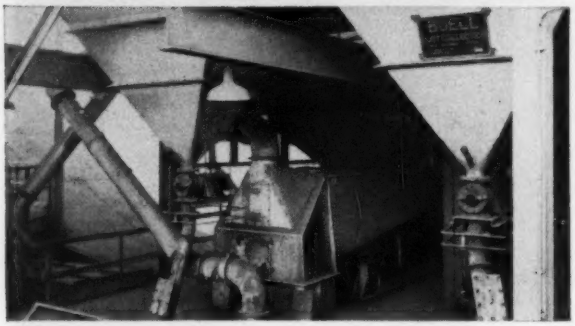

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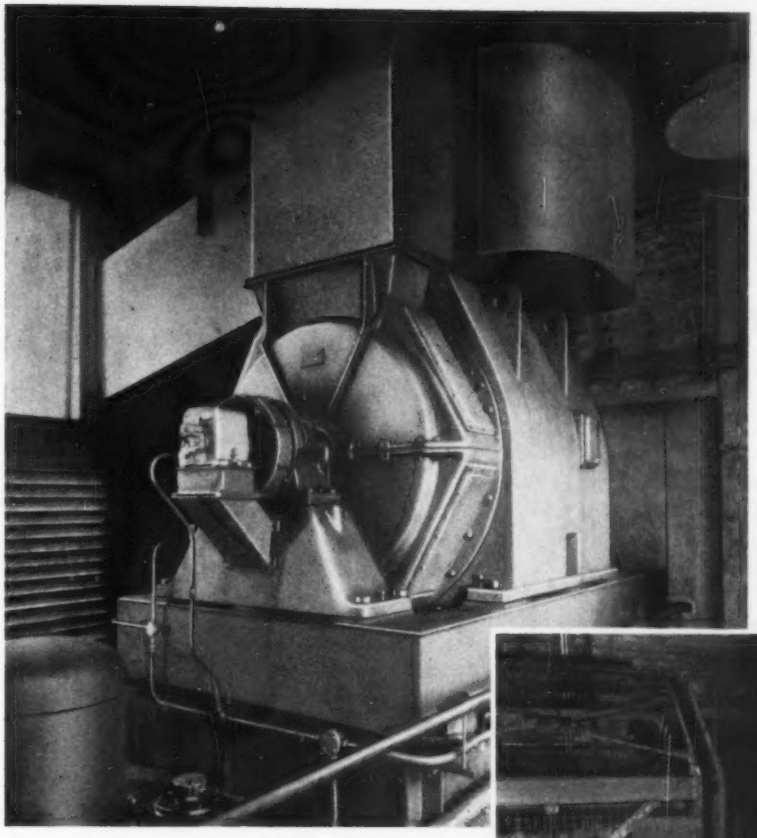
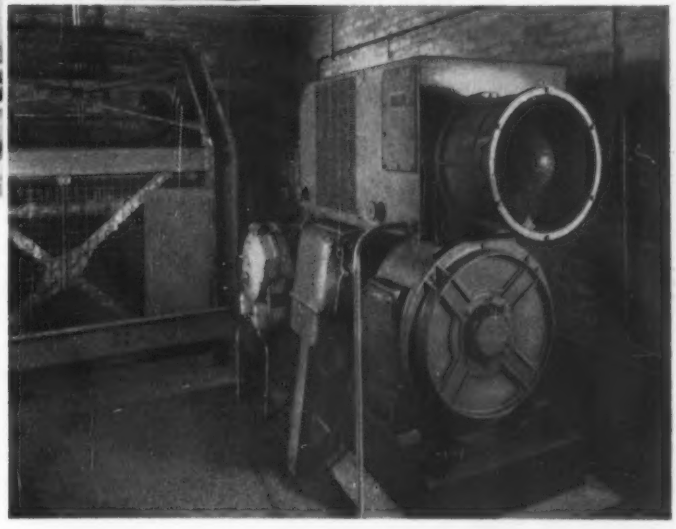


Left. Slip-ring induction motor driving sinter fan. Closed air circuit with air/air heat exchanger, with integral fans. External air ducted from outside source. Rating 1350 h.p., 743 r.p.m.

Below. 'Revcon' induction motor for skip hoist drive. Motor speed steps of 1400, 550, and 150 r.p.m. Closed air circuit type with air/air heat exchanger, with independent motor driving fans for circulation of internal and external air.



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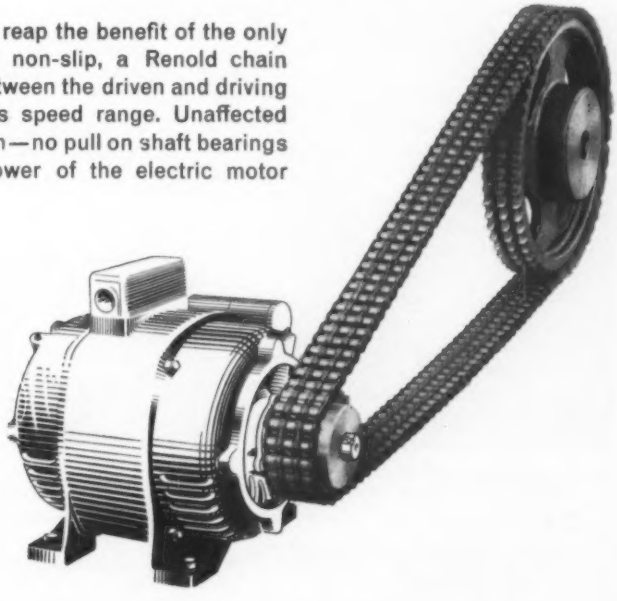

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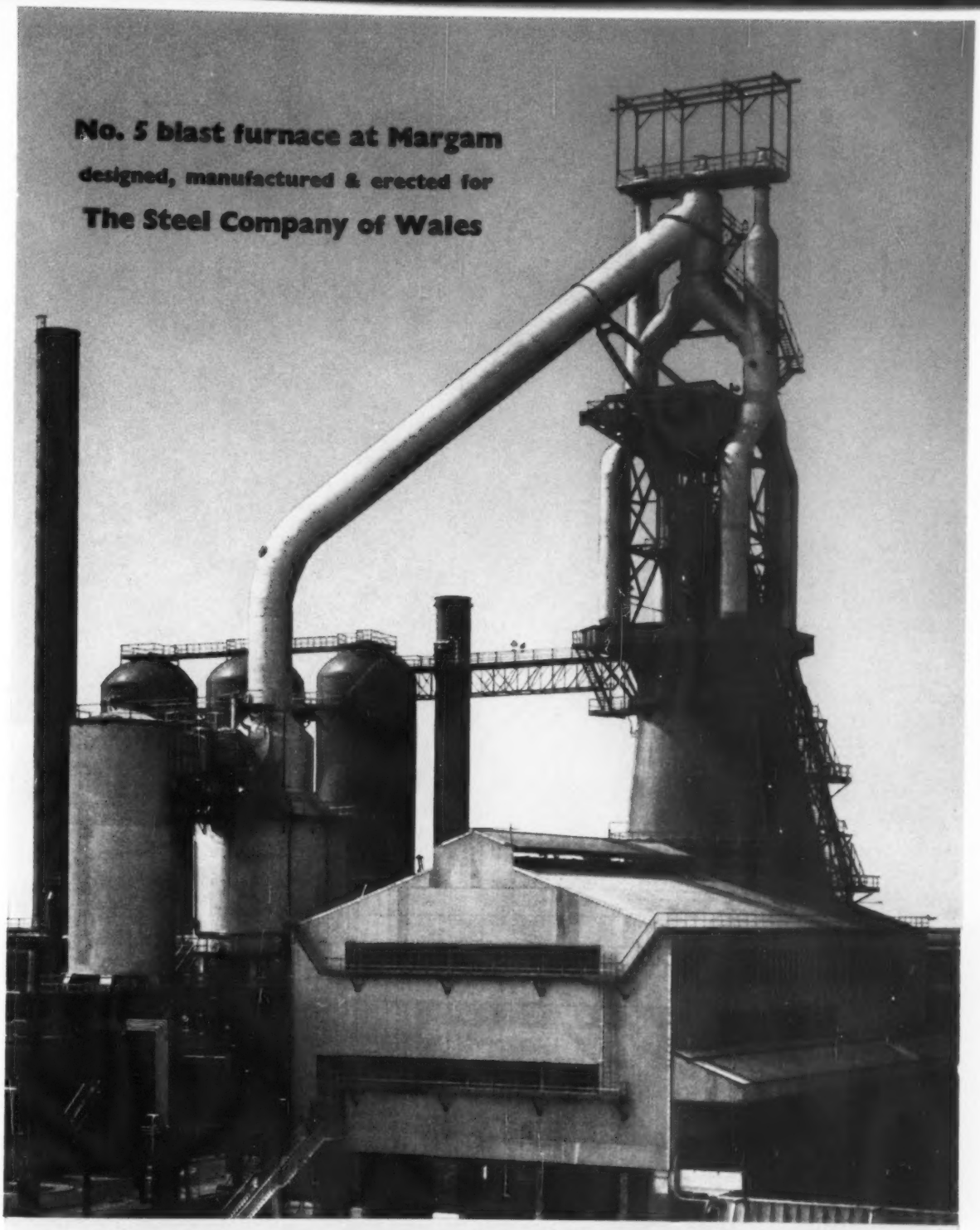

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